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THE ADJUSTMENT OF GRADES TO FIT CLASSIFICATION OF STUDENTS ACCORDING TO I. Q.

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Mental tests have been found to be of great value in the classification of students for instructional purposes into groups of approximately equal mental ability. This scheme is being used with success in many of our schools, but its more universal adoption has been seriously retarded as it has a tendency to break down the older conceptions of student-grading. Obviously, where pedagogical practice determines the student's grade not from standardized tests but rather from his percentile rank in the class, the grade assigned would mean little or nothing if it is to be used as a means of comparing achievement of students throughout the school, or school system. The superior student in a class of low intelligence rating would not necessarily be the equal of a superior student in a class of high I. Q. individuals.

This paper will present a simple method for adjusting grades in a school, or school system, where the student body has been grouped into classes of about the same mental ability, and where the grading of these students for achievement is dependent upon the individual's rank in his class.

The paper is divided into two parts. First, we will consider the interpretation and application of the method derived. Second, we will present the mathematical and statistical theory underlying the method.

INTERPRETATION AND APPLICATION OF METHOD.

Any attempt which reduces the student's grade and his I. Q. to the same scale, and compares directly, is of course assuming perfect correlation between I. Q. and student achievement. The degree of correlation between these two has been found to

vary considerably with different subjects. It is therefore apparent that in our investigation we must consider the correlation ratio between I. Q. and student achievement in a given study. For much of the curriculum this ratio (r) has been computed, but where it is lacking it may easily be determined from a statistical study of the I. Q. in its relationship to the results of some standardized or uniform test. Once determined for a given subject r need not be recomputed, unless radical changes in subject-objectives or content are made.

The method of adjusting grades to be presented here uses the t-scale of the probability integral as the unit of comparison between the student's rank in the school and his rank in a specific class. For both school and class the value of "t" corresponding to the individual's percentile rank is defined by the probability integral

$$\frac{\text{Percentile rank}}{100} - .5 = \int_{-\infty}^{t} \frac{e^{\frac{-t^2}{2}}}{\sqrt{2\pi}}\,dt.$$

For convenience a table for conversion from percentile rank to the corresponding t-scale rank is given.

% rank	t-scale equivalent	% rank	t-scale equivalent	% rank	t-scale equivalent
0	−2.50*	34	−0.41	67	0.44
1	−2.33	35	−0.39	68	0.47
2	−2.06	36	−0.36	69	0.50
3	−1.89	37	−0.33	70	0.53
4	−1.75	38	−0.31	71	0.55
5	−1.65	39	−0.28	72	0.58
6	−1.56	40	−0.25	73	0.61
7	−1.48	41	−0.23	74	0.64
8	−1.40	42	−0.20	75	0.68
9	−1.34	43	−0.18	76	0.71
10	−1.28	44	−0.15	77	0.74
11	−1.23	45	−0.13	78	0.77
12	−1.17	46	−0.10	79	0.81
13	−1.13	47	−0.08	80	0.84
14	−1.08	48	−0.05	81	0.88
15	−1.04	49	−0.03	82	0.92
16	−1.00	50	0.00	83	0.96
17	−0.96	12	0.03	84	1.00
18	−0.92	53	0.05	85	1.04
19	−0.88	54	0.08	86	1.08
20	−0.84	55	0.10	87	1.13
21	−0.81	55	0.13	88	1.17
22	−0.77	56	0.15	89	1.23
23	−0.74	57	0.18	90	1.28

24	−0.71	58	0.20	91	1.34
25	−0.68	59	0.23	92	1.40
26	−0.64	60	0.25	93	1.48
27	−0.61	61	0.28	94	1.56
28	−0.58	62	0.31	95	1.65
29	−0.55	63	0.33	96	1.75
30	−0.53	64	0.36	97	1.89
31	−0.50	65	0.39	98	2.06
32	−0.47	66	0.41	99	2.33
33	−0.44			100	2.50*

*Actually infinite but cut off at the customary 2.5 for convenience.

If t' is the t-scale equivalent of the student's percentile rank in the class (determined from table), and t is the t-scale equivalent of his percentile rank in the school then

$$(16) \qquad t = \frac{t'\sqrt{\sigma^2_x - r^2(\sigma^2_x - \sigma^2)} + rx_m}{\sigma_x}$$

where

σ_x is the standard deviation from the mean I. Q. of the school.
σ is the standard deviation from the mean I. Q. of a specific class.
r is the correlation ration between I. Q. and student achievement.
x_m is the mean I. Q. of class less the mean I. Q. of school with algebraic sign.

The following illustrative problem might aid in demonstrating one of the applications of the formulas:

The Harrison Technical High School of Chicago groups its students into classes of about the same I. Q. The student is graded for achievement according to his rank in the class. This rank determines his grade, the marking system being of the S-E-G-F-D type. A study of twenty algebra classes was made and the following data were collected:

For the Classes as a Whole.

1—The percentage distribution of grades.
2—The mean I. Q. of the students.
3—The deviation from the mean I. Q.
4—The correlation ratio between I. Q. and achievement as indicated by correlating I. Q. with the results obtained by giving all the students the Hotz Standardized Algebra Scales. The mean of the ratios obtained for the separate tests was found to be .45.

For the individual classes data were available which told the percentage distribution of grades, the mean I. Q. of the class, and the deviation (standard) from the mean.

The problem is to readjust the grades of the class making them conform with a grading based upon a ranking of the individuals of the entire school. Tabulating the data:

For the Twenty Classes.

Grade Distribution.

S or below	100%	t-scale equivalent 2.50 or below.
E or below	89%	t-scale equivalent 1.23 or below.
G or below	58%	t-scale equivalent 0.20 or below.
F or below	32%	t-scale equivalent -0.47 or below.
D or below	8%	t-scale equivalent -1.34 or below.

Mean I. Q. 97
Standard deviation from mean I. Q. (σ_x) 9.86
Correlation ratio I. Q. vs. test (r) 0.45

For a Specific Class.

Grade Distribution.

S or below	100%	t-scale equivalent 2.50 with a mean t-rank of S 2.03
E or below	94%	t-scale equivalent 1.56 with a mean t-rank of E 0.96
G or below	64%	t-scale equivalent 0.36 with a mean t-rank of G -0.28
F or below	18%	t-scale equivalent -0.92 with a mean t-rank of F -1.71
D or below	0%	

Mean I. Q. of Class 87.

Standard deviation from mean I. Q. of class (σ) 5.93.

**As we are dealing here with a group rather than an individual it will be necessary to consider the entire group as having a percentile rank equal to the mean of the limiting per cents for that group. In cases where we know the position of the individual grades, or the percentile rank of the student the adjustment may be made with a greater degree of accuracy.*

Consider first that group in the class whose grade was "G." The mean t-rank of students in this group was -0.28, hence t' is -0.28. Substituting in (16) to find the corresponding rank of the "G-group" in the school

$$t = \frac{-0.28\sqrt{97.22-.2(97.22-35.16)+.45(87.-98)}}{9.86}$$

$$= -0.76$$

We note that -0.76 in the t-ranking for the school is between the limits -0.47 and -1.34 which would carry the mean of the "G-group" of the class into the "F-group" for the school. Similarily it will be noted that the "F-group" is also shifted downward whereas the "S" and "G" groups maintain their position although the ranking is lowered somewhat.

Mathematical and Statistical Theory.

Notation.

N—Total number in school taking the subject under investigation.
X—The I. Q. of an individual.
Y—Score of the individual in some uniform achievement rating scheme.

$\overline{X}$—Mean I. Q.'s of the school.
$\overline{Y}$—Mean achievement score of individuals.
$x = X - \overline{X}$
$y = Y - \overline{Y}$
σ_x—Standard deviation of I. Q.'s of school from the mean.
σ—Standard deviation of I. Q.'s of class from the mean X_m of I. Q.'s of class.
σ—,Standard deviation of achievement scores of school from mean.
r—Correlation ratio of I. Q. with achievement score.

In order to have a standard of comparison the theory uses a hypothetical achievement score which is uniform for the entire school. This disappears in the process of determining the formulas already discussed presenting itself only in the form of the correlation ratio between achievement and I. Q. The method of determining this has already been considered.

Assuming normal distribution for I. Q. and achievement score, the number of students having I. Q. between x and $(x+dx)$ and score between y and $(y+dy)$ is determined from the normal correlation surface to be

$$(1)\quad F dx dy = \frac{N}{2\pi\sigma_x\sigma_y\sqrt{1-r^2}} e^{-\frac{1}{2(1-r^2)}\left(\frac{x^2}{\sigma^2_x} + \frac{y^2}{\sigma^2_y} - \frac{2rxy}{\sigma_x\sigma_y}\right)} dx dy.$$

The total number of students in the school having an I. Q. between x and $(x+dx)$ will therefore be

$$(2)\quad N_x dx = dx \int_{-\infty}^{+\infty} F dy.$$

Integrating (2)

$$(3)\qquad N_x dx = \frac{N e^{-\frac{2\sigma^2_x}{x^2}}}{\sqrt{2\pi}\sigma_x}.$$

Solving (3) for N and substituting in (1)

$$(4)\ F dx dy = \frac{N_x e^{\frac{x^2}{2\sigma_x^2} - \frac{1}{2(1-r^2)}\left(\frac{x^2}{\sigma_x^2} + \frac{y^2}{\sigma_y^2} - \frac{2rxy}{\sigma_x\sigma_y}\right)}}{\sqrt{2\pi(1-r^2)}\,\sigma_y} dx dy.$$

It is obvious that in (4) the coefficient of N_x represents the fractional part of the students having I. Q.'s between x and $(x+dx)$ that have achievement scores between y and $(y+dy)$.

Take now a class composed of n students, $n_1\,dx$ of which have I. Q.'s between x_1 and (x_1+dx), n_2dx of which have I. Q.'s between x_2 and (x_2+dx), etc.

$$n = (n_1dx+n_2dx+n_3dx\text{- - - - - - - -}+n^k dx)$$

The number of n_1dx having an achievement score between y and $(y+dy)$ will be n_1dx multiplied by the fraction of students having I. Q. between x_1 and x_1+dx of the entire school receiving this score, that is

$$(5)\qquad \frac{n_1dx\, e^{\frac{x_1^2}{2\sigma_x^2} - \frac{1}{2(1-r^2)}\left(\frac{x_1^2}{\sigma_x^2}+\frac{y^2}{\sigma_y^2}-\frac{2rx_1y}{\sigma_x\sigma_y}\right)}}{\sqrt{2\pi(1-r^2)}\,\sigma_y}\, dy.$$

The total number of students in the class of n having this same achievement score will be represented by the sum of the smaller groups, that is

$$(6)\qquad \sum_{i}^{1\,.\,.\,.\,k} \frac{n_i dx\, e^{\frac{x_i^2}{2\sigma_x^2} - \frac{1}{2(1-r^2)}\left(\frac{x_i^2}{\sigma_x^2}+\frac{y^2}{\sigma_y^2}-\frac{2rx_iy}{\sigma_x\sigma_y}\right)}}{\sqrt{2\pi(1-r^2)}\,\sigma_y}\, dy.$$

Theoretically correct the above is not of practical application. It will therefore be necessary to further assume that these n students are distributed in the smaller groups according to a normal distribution, having a mean of X_m (not necessarily $\overline{X}$), and a standard deviation from this mean of 6. That is

$$(7)\qquad n_i dx = \frac{ne}{\sqrt{2\pi}\sigma}^{-\frac{(x_i-x_m)^2}{2\sigma^2}} dx.$$

where $x_m = X_m - \overline{X}$.

Substituting (7) in (6) and replacing the finite sum by an integral, (6) becomes:

(8)

$$\frac{n\,dy}{2\pi\sqrt{(1-r^2)}\,\sigma_y\sigma}\int_{-\infty}^{+\infty} e^{\frac{x^2}{2\sigma_x^2}-\frac{1}{2(1-r^2)}\left(\frac{x^2}{\sigma_x^2}+\frac{y^2}{\sigma_y^2}-\frac{2rxy}{\sigma_y\sigma_y}\right)-\frac{(x-x_m)^2}{2\sigma^2}}\,dx.$$

Integrating we have the following expression for the total number of the n students in a class having an achievement score between the limits y and $(y+dy)$;

(9)

$$\frac{n}{\sqrt{2\pi}\,u}\,e^{\frac{-\left(y-\frac{\sigma_y}{\sigma_x}rx_m\right)^2}{2u^2}}\,dy.$$

Hence the distribution of achievement scores within a given class is according to the equation:

(10)

$$f(y) = \frac{1}{\sqrt{2\pi}\,u}\,e^{\frac{-\left(y-\frac{\sigma_y}{\sigma_x}r_m\right)^2}{2u^2}}$$

where $u^2 = \sigma_y^2 1-r^2\left\{\frac{\sigma_x^2-\sigma^2}{\sigma_x^2}\right\}.$

For the entire school the distribution, being normal in character, is:

(11)

$$F(y) = \frac{1}{\sqrt{2\pi}\,\sigma_y}\,e^{\frac{-y^2}{\sigma_y^2}}$$

Since the scale of marking is immaterial replace y by w where

$$w = \frac{y}{\sigma_y}.$$

Then (10) becomes:

$$\frac{-\left(w-\frac{r}{\sigma_x}x_m\right)}{2\gamma^2}$$

$$f(w) = \frac{1}{\sqrt{2\pi}\,\gamma}\, e$$

where $\gamma^2 = 1 - r^2\left(1 - \frac{\sigma^2}{\sigma_x^{\,2}}\right)$

and (11) becomes

$$F(w) = \frac{1}{\sqrt{2\pi}}\, e^{\frac{-w^2}{2}}$$

Here $F(w)dw$ and $f(w)dw$ represent the fraction of the school and class respectively, with an achievement score on a w-scale between w and $(w+dw)$. Hence the entire portion (p) of the class having a grade equal to or below w is the integral

$$(12) \qquad p = \int_{-\infty}^{w} \frac{1}{\sqrt{2\pi}\,\gamma}\, e^{\frac{-(w - \frac{r}{\sigma_x} X_m)^2}{2\gamma^2}} dw,$$

while the portion of the school (P) having a grade equal to or below w will be the integral

$$(13) \qquad P = \int_{-\infty}^{w} \frac{1}{\sqrt{2\pi}}\, e^{\frac{-w^2}{2}} d\imath.$$

Obviously those students having the same w or achievement score, should when the entire school is the basis, receive the same grading. Hence in both integrals we will set $w = w$. Defining a t-scale of ranking so that the portion (P) of the school t or below will be

$$(14) \qquad P = \int_{-\infty}^{t} \frac{l}{\sqrt{2\pi}}{}^{\frac{-t^2}{2}} dt$$

$$= \int_{-\infty}^{w} \frac{l^{\frac{-w^2}{2}}}{\sqrt{2\pi}}\, dw$$

$\therefore\ t = w.$

and for the class so that the portion $(p)t'$ or below will be

$$(15)\qquad p = \int_{-\infty}^{t'} \frac{e^{\frac{-t^2}{2}}}{\sqrt{2\pi}}\, dt$$

$$= \int_{-\infty}^{t' = w - \frac{r}{\sigma_x} Xm} \frac{e}{\sqrt{2\pi}}^{\frac{-t^2}{2}}\, dt$$

Since

$$t' = \frac{w - \frac{r}{\sigma_x} Xm}{\gamma},$$

Solving for t after substituting $w = t$ and $\gamma^2 = 1 - \gamma^2 \left(\frac{1-\sigma}{\sigma_x{}^2}\right)^2$ we have the completed formula demonstrated in the first part of the discussion.

$$(16)\qquad t = \frac{t'\sqrt{\sigma_x{}^2 - r^2(\sigma_x{}^2 - \sigma^2)} + rxm}{\sigma_x}$$

A VISIT TO THE BORAX PLANT OF THE AMERICAN TRONA CORPORATION AT SEARLES LAKE, CALIFORNIA.[1]

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Those attendants at the Los Angeles meeting of the American Chemical Society last August who went out on the special train for chemists had an unusual opportunity to enjoy certain pre-convention trips, among others visits to such places as Pike's Peak, the Grand Canyon of the Colorado, and so on. Of a more chemical flavor, however, was the visit to the citrus groves at Riverside, California.

Opportunity was afforded returning chemists to take advantage of certain post-convention trips. The outstanding one was the visit to the plant of the American Trona Corporation at Searles Lake, Trona, California, where, as Slosson's Science Service says, "On the Mojave Desert is located the Verdun Fortress of the American Potash Industry."

The American Trona Corporation invited the chemists to be their guests over the week-end. A party of about forty assembled at the Biltmore Hotel Saturday night and were taken by autos to the Southern Pacific Station where they boarded special sleepers at 11:30 p. m. Immediately upon arrival at Trona Sunday morning, Manager Wieweg and other representatives of the Trona Corporation met the party and conducted us to the Corporation's dining room. After a substantial breakfast Manager Wieweg and R. W. Mumford made short welcome speeches. The forenoon was spent at the Lake. After dinner the party visited the research laboratories and then was taken out to the Company's swimming pool, five miles distant from the plant, where many of the visitors enjoyed themselves in one of the finest swimming pools in California. After supper appropriate short talks were made about the plant and appreciative votes of thanks were passed to the Trona Corporation. The party then left by sleeper and arrived in Los Angeles early Monday morning.

The trip was one never-to-be-forgotten by those who had the opportunity to witness the scenes of the one potash enterprise which, after seven years' battle against terrific odds, still survives on American soil. The difficulties overcome were enormous,

[1]Read at the Feb. 13, 1926, meeting of the New England Association of Chemistry Teachers. Published with the permission of the American Trona Corporation.

but warranted the effort because it is estimated that the Searles Lake District could meet the potash demands of the whole United States even if the nation could be blockaded for a hundred years.

First let me describe the lake region, then indicate briefly the steps in the process of recovery of potassium chloride and of borax, and then give some of the more technical details of the process. For much of the data I am indebted to Mr. W. E. Burke, Director of the Research Department of the Corporation, and to the efficient guides who piloted us through the works.

Searles Lake is situated 200 miles northeast of Los Angeles and 50 miles west of Death Valley in the extreme northwestern corner of San Bernardino County. It is a salt deposit about 1600 feet above sea level. At one time it was a great alkali lake 385 square miles in extent and acted as a great solar evaporating pond for the waters of the Owens River carrying salts leached from the southern Sierra Nevada Range. After centuries of accumulation and concentration of volcanic salts, an upheaval changed the course of the Owens River and the great salt lake in the Searles Basin dried up, leaving a bed of salts 35 square miles in extent and from 70 to 100 feet deep. Mud and sand have washed down from the hills so the exposed salt surface is now only 12 square miles in extent.

The surface of the central salt deposit is a firm, level crust of common salt crystals so hard and compact that it will support the weight of an automobile or tractor.

Below the surface the crystalline structure is of an open cellular nature. Probably between 50 and 70 per cent, by volume, of the deposit consists of the intergrown crystals of the various salts, Trona, Borax, Glaserite, Hanksite, and Sodium Chloride, which make up the major part of the crystal structure. The main part is shown in the following list:

Halite	$NaCl$
Trona	$Na_2CO_3 . NaHCO_3 . 2H_2O$
Borax	$Na_2B_4O_7 . 10H_2O$
Glaserite	$K_3Na(SO_4)_2$
Hanksite	$2Na_2CO_3 . 9Na_2SO_4 . KCl.$

The spaces between the crystals are filled with a dense brine. The level of the brine is usually within a few inches of the level of the salt structure, an inch or two below it in summer, and a few inches above it in winter. Brine can be easily pumped from the cellular structure.

Automobiles took us out several miles over the salt surface, as if we were driving on the ice covered surface of a New England lake. Its texture was that of our snow-ice. A hastily spaded hole showed the brine, and a handful of the moist salts could be scooped out. These were often colored a bright red due to bacteria but the red disappeared slowly on exposure to air. Pipes are sunk to a depth of about 75 feet below the surface whence the brine rich in potash and borates is pumped to the surface and piped to the plant several miles away. Occasionally the surface of nearly pure Sodium Chloride (98 per cent pure) is harvested and sold as crude salt for the ice cream industry, soap making, etc. Near one edge of the lake are banks of crude Trona (Na_2CO_3. $NaHCO_3$. $2H_2O$). This finds a use in mineral flotation as a substitute for soda ash.

The Trona process is one of fractional crystallization and is based on a scientific knowledge of the effects of temperature and concentration upon the solubilities of the various salts in Searles Lake brine.

It consists essentially of the following steps:

1st. A partial evaporation of the brine in triple effect evaporators. During this step the valuable constituents of the brine, Potassium Chloride and Borax, concentrate, and the less valuable constituents crystallize from the solution and are eliminated from the process.

2nd. A cooling of the hot concentrated liquor to a desirable temperature for the crystallization of a certain portion of the potassium choride.

3rd. A separation of the cooled liquor and the crystalline potassium chloride.

4th. A further cooling of the liquor to a desirable temperature for the crystallization of a certain portion of the borax.

5th. A separation of the cooled liquor and the crystalline borax.

6th. A recrystallization of the borax.

The composition of the crystalline deposit given above does not determine the process of the extraction, however, because the brine and not the crystal deposit is used. The composition of the brine is practically constant at all times and is shown in the following list:

$NaCl$	16.50%	Na_2S	0.020 %
Na_2SO_4	6.82%	As_2O_3	0.019 %
KCl	4.82%	CaO	0.0022%
Na_2CO_3 and $NaHCO_3$	4.80%	Fe_2O_3 and Al_2O_3	0.0020%

$Na_2B_4O_7$	1.51%	NH_3	0.0018%
Na_3PO_4	0.155%	NaI	0.0014%
NaBr	0.109%	Sb_2O_3	0.0006%
LiCl	0.021%	Organic (Sodium Humate)	0.003 %

This totals approximately 34.8 per cent of solids to 65.2 per cent of water.

As stated before, the pumped brine is piped to the plant,—a massive piece of chemical engineering skill situated as it is right in the heart of the desert country. Visitors were given access to all parts of the plant and afforded opportunity to study intimately the processes involved.

Twenty-four hours supply of brine (500,000 gallons) is stored in two tanks from which it flows by gravity to the "evaporator feed make-up sumps" as needed. The brine is mixed with plant mother liquor in about the ratio of 3 to 1 by volume. This mixture is then pumped to the evaporators.

If low temperature or solar evaporation were used the KCl and the borax would crystallize out along with the chlorides, carbonates and sulfates of sodium and potassium and there would be no separation of the sodium and the potassium salts.

By using triple effect evaporator pans and flowing the brine current opposite to the flow of steam the temperature is increased as evaporation proceeds.

Each effect has a capacity of 30,000 gallons, and the three units of three effects each compose one of the largest evaporator installations in the world. About 3,500,000 pounds of water are evaporated daily, and 700 tons of "waste salts" removed during evaporation. Both KCl and borax have much greater solubilities hot than cold. On the other hand the "waste salts" (NaCl, burkeite, $Na_2CO_3 \cdot 2\ Na_2SO_4$, and Na_2CO_3, H_2O) all have "inverted solubility curves" in these liquors; i. e., more soluble cold than hot. Therefore on cooling the concentrated liquor, only KCl and borax can be separated up to a definite point.

Cooling is carried out in three stages. First the hot liquor is subjected to vacuum in a continuous vacuum cooler where the boiling cools the liquor from 110° to 60° C., with the separation of a considerable portion of the KCl. Then a series of double-tube continuous coolers using cold water and refrigerated brine in the outer tubes, reduces the temperature rapidly to 35° C. These coolers discharge into continuous settlers from which the sludge of KCl crystals flows to centrifuges while the clear liquor

(Mother Liquor No. 1) flows to the borax department. The liquor is supersaturated with $Na_2B_4O_7 \cdot 10\ H_2O$ to the extent of 20° C. temperature drop, but this salt is very slow in crystallizing. Therefore with rapid removal of KCl, no trouble is experienced from the separation of borax with the KCl. The KCl is given a slight wash and is ready for shipment. Belt conveyors take it from beneath the centrifugals and discharge it directly into box cars. The demand is so great that no storage piles can accumulate.

The Mother Liquor No. 1 is again cooled (after sufficient dilution to keep KCl in solution) to 20°C. and is discharged to large settling vats where the liquor stands about 12 hours for the separation of crude borax. The Mother Liquor No. 2 is then decanted off and returned to the evaporator feed make-up sumps, while the borax sludge is leached with a small amount of water to remove certain impurities, and is then crystallized, dried, screened and sacked mechanically for shipment.

At one time it was planned to pipe the brine 200 miles to Los Angeles and recover the KCl and borax there. In that case much of the waste salts would probably have been run into the ocean. By having the plant at the lake all the waste liquors and mother liquors are run back into the lake, thus carrying out a distinctly conservation policy.

The visitors were greatly impressed with the up-to-date plant, the efficient management, and the unstinted expense and thoughtfulness of the Company in providing attractive living conditions for the employes. They considered it a rare privilege to accept the hospitality of the Company and see first hand the developing of one of America's basic natural resources.

SURVEY OF RECENT PROGRESS MADE IN ZOOLOGY.

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(Continued from May.)

Genetic research is constantly bringing to light new cases of cooperation of several or many factors in the production of a single character, and it now appears possible that all the chromosomes may be concerned in the production of every character. Beyond this it is evident that every character is produced during development by an activity in which the cytoplasm, and what we call the organism as a whole, play a most important part. The value of the chromosome theory does not lie in our identification of this or that determiner but in its practical importance as a means of experimental analysis.

The determinative action of the cell nucleus and its components was thus finally placed beyond doubt, but as before stated, no investigator today would maintain that the chromosomes are the sol eagents of heredity. On the contrary, it has been experimentally proved by experiments on the development of egg fragments by Boveri, Driesch, Fischel, and others, that the cytoplasm plays an important part in development. With reference to this problem, much interest has been aroused in recent years by the study of those cytoplasmic bodies known as mitochondria and chondriosomes. These bodies are now believed to play an important part in the chemical activities of cells, and perhaps also in differentiation. By Benda and Meves they have been regarded as representing a mechanism of cytoplasmic heredity comparable in importance with that represented by the chromosomes. This view, still very far from substantiation, remains a subject of controversy, and must be taken with proper skepticism. They play an important part in the formation of germ cells. During cell division they are distributed with approximate equality to the daughter cells. An important group of observers have ascribed to them the power of independent growth and division, and consider them of fundamental importance in histogenesis, being the source of more specific cell compo-

nents, such as plastids, fibrillæ, neurofibrils, and myofibrils, secretory and storage granules, yolk, fat, pigment, etc.

By more improved methods of technique still another group of cell bodies has been brought to our attention in the last few years. This is the so-called Golgi apparatus which has been shown to be of wide occurrence among cells. Concerning the function and significance of the Golgi elements even less is known than in the case of the chondriosomes. The important fact has recently been made clear that they play an important part in the formation of the acrosome during spermatogenesis, and that they are also concerned in the process of secretion.

Researches in experimental cytology, embryology, and genetics have taught us that the undeveloped egg possesses a structure both in its cytoplasm and nucleus, the parts of which are definitely related to the formation of certain organs of the embryo. It does not follow, however, that every separate inheritable character of the animal is represented by a separate unit or determinant in the germ. Researches in experimental embryology have shown that certain characters are caused by the action upon one another of parts already in existence—that the organism as a whole, through the interaction of its parts, is responsible for the development of many characters. Thus, if the optic vesicle is destroyed, a lense is not developed; but if the vesicle is intact and ectoderm from some other part of the body is grafted over it, a lense will form the same as from the normal lense-forming cells.

Experimental situs inversus has shown us that if a part be cut from an embryo and reversed in position, not only will the organs developing from it be reversed, but this will also incite a corresponding change in other parts which were not touched in the operation.

Regeneration experiments on worms have shown that new structures—heads and tails—are developed over the cut ends of the nerve cord. Limb buds of Amphibian embryos transplanted to strange positions in normal individuals continue to develop and acquire a normal nerve supply from the nervous system of the host. Thus there

is shown to be a definite interaction of parts of the organism as a whole in both ontogeny and regeneration which bring about the development of parts just as truly as though they were represented by definite units in the germ.

The chief interest in the results obtained through genetic researches is not centered primarily in the mere facts of heredity, but rather in the key that the solution of these problems has given us to the more thorough understanding of evolution. Following the microscopic study of the germ cells and the development of the mutation theory which made known to us the mechanism of Mendelian heredity, suddenly as by a kaleidoscopic turn, the fundamental problem of organic evolution crystallized before our eyes into an explanation of how it is brought about.

The Darwinian theory of natural selection is now almost universally accepted in polite zoological society. In this theory it should be borne clearly in mind that evolution was not due to an orderly response of the organism to its environment, not to use and disuse, not to an innate principle of living matter, and not to purpose either within or without, but to chance, by casual accidents. Darwin was searching for a physical cause of variation, but not finding it he assumed it. No two individuals being identical, the fittest survived the struggle for existence, and as a consequence their offspring by competition replaced the others. Selection does not produce anything new, but only more of a certain kind. Johansen has shown that the frequency distribution of a pure line is due to outside factors, that the individuals all have the same germplasm. Therefore, the view taken by some of Darwin's contemporaries, who adopted the sliding scale interpretation as a cardinal feature could not be maintained. By this is meant that what is gained in one generation forms the basis for further gains in the next. If, therefore, selection cannot produce anything new, how can it be an agent in evolution, which means the production of more new things? The chromosome theory of heredity and the mutation theory as interpreted by Morgan and his followers has supplied this explanation.

Late developments in connection with genetics and evolution have again suggested the possibility of some basis of fact in the Lamarckian conception of the inheritance of somatic modifications. Chief among these researches is the work of Guyer on the inheritance of lense defects in rabbits. By carefully controlled experiments he has found that certain defects are transmitted through both the male and female line for several generations. He suggests the interesting possibility that in the light of endocrinology all tissues may secrete into the blood stream certain substances which modify the development and activities of other parts including the germ plasm and thus effect heritable changes.

Recent years have also seen the development of an interesting method for the investigation of cells and tissues kown as micro-dissection or micro-vivisection. The method established by Barber and Kite and developed particularly by Chambers has led to a fuller knowledge of the constitution of the living egg, the method of penetration of the sperm, and of the physical condition of the nucleus and cytoplasm. The method is still in its infancy and although it lacks much in standardization and refinement of technique, it holds great promise for the future. The operations are performed on living cells suspended in hanging drops of an appropriate normal fluid by means of a micro-dissection needle, devised by Barber. Such needles are made by drawing out small glass rods to an extremely fine point, and can be used to puncture, cut, tear or displace the living cell substance under high powers of the microscope. Accurate control of these operations is made possible by a number of simple mechanical devices readily attached to the stage of the microscope.

The problem of artificial parthenogenesis has continued as an ever-fruitful field of productive research. We are all familiar with the early observations of Hertwig, Morgan, and Mead, which prepare the way for the brilliant discovery by Loeb that after appropriate treatment the unfertilized egg of the sea urchin may be activated to develop and produce normal larvae, and how this work was soon confirmed and extended to a great number of other animals including the vertebrates, by a

number of workers. A great number of later researches have been directed towards a solution of the physiological and morphological problems involved. This has been of special importance in the interpretation of the processes in normal development because of the opportunities here afforded to separate out and to a greater extent experimentally control the various phenomena, normally too closely associated to be analyzed by observation alone.

Loeb concluded that complete parthenogenetic activation involved two phases: one cytolytic, the other corrective. The work of Just has thrown doubt on the validity of the conclusion, since it was shown that perfect activation might be effected by one agent alone. For this and a number of other reasons the theory has now been supplanted by Lillie's fertilizing theory as the most adequate explanation of the physiological processes involved. Concerning the morphological phases of the question, there are two outstanding theories. The first is that of E. B. Wilson, who maintained that the cleavage centers of the artificially activated egg arose from the division of a primary egg center, and that although cytasters are true asters in every sense of the word, they are, nevertheless, epiphenomena in the process. The second view was that of M. Herlant, who maintained that the artificially activated egg can develop a single cleavage center only, and that this cannot divide. The pipolar figure capable of division was made possible through union with a cytaster produced by a second treatment. Thus the cytaster, according to this view, plays a very essential role in development following artificial activation. In the light of later researches by Fry and Tharaldsen, it appears that the latter conclusion was in error, and that Wilson's original conclusions were sustained.

In the field of experimental embryology, an important line of progress has been made by artificially separating the blastomeres of early cleavage stages. By this means it has been possible to obtain an insight into the problems of regulation and adjustment during development. In studies of cell lineage, the history of the value of each of the early blastomeres in the future embryo has been

ascertained, and thus the cellular genesis of the various parts of the body have been traced.

These two lines of research have led into some of the most interesting and deeply philosophical problems of Zoology—the question of localization and differentiation. How do the various parts of the developing organism take on their specific character in the course of development? How do they come to form an orderly system in space and time? These discussions gave rise to Nageli's "Idioplasm Theory," the "Theory of Germinal Prelocalization," the "Mosaic Theory of Development," and to the theory of the "Development of the Organism as a Whole."

To one group of observers the multicellular body in general is comparable to an assemblage of individual cells which have undergone a high degree of integration and differentiation, so as to constitute essentially a cell state. To the other group, such as Whitman, Sedgwick, Dobell, Child, and Ritter, the organism is looked at as something over and above the cells that constitute it. Childs has emphasized the general importance in metabolic gradients as an expression of functional polarity. In support of this he has proved by a study of susceptibility to the action of poisons and narcotics that such gradients undoubtedly exist both in the organism as a whole and the individual cells. This has added new weight to the early view that the polarity of the ovum may thus be determined by its environment. That such localized conditions of environment may be concerned in the localizing activities of the embryonic development seems to be clearly established. Thus we can in some fashion see how by interaction of parts or the influence of the organism as a whole on the development of its component parts, all localization may originally be conditioned by the external environment.

On the other hand, the first group maintain that the specific reactions of the developing embryo depends upon the organization of the individual blastomeres. But, directly or indirectly, formative stimuli from without may play a part in all localizing processes. It seems clear, however, that external formative stimuli are but limiting conditions in which the egg adjusts itself. Thus

the organismal conception and the elemental conception of differentiation, both expressing part of the truth, may eventually meet on a common ground of understanding.

Following Waldeyer's announcement of the neurone theory there has been a marked reawakening of research in the field of neurology. The theory aroused a sharp controversy, and its stimulus turned many acute observers to the minute study of nerve cells. Much experimental work has been done on the question of the nature of the nervous impulse and the determination of the function of the various parts of the nervous system. Conspicuous among these are recent experiments on the function of the cerebral cortex which seem to have badly shocked our time-honored theories with regard to this structure. The latest development in morphological work on nerve elements is the investigation of the neurometer system in the protozoa. Sharp, Yocum, and Taylor have clearly demonstrated the presence and functional significance of a fibrous structure in several protozoa. By the application of microdissection methods they have demonstrated that the destruction of certain of these fibers destroyed coordination between membranelles and cirri, thus demonstrating their conductile and coordinating function.

The study of parasitology and the development of the department of public health as an independent branch of the subject has had its real origin within the last twenty-five years. We have almost ceased to wonder at its incredible prodigies of achievement, yet in some directions they retain a hold on our imagination that daily familiarity can not shake. Zoology is rendering her most direct and personal service to human welfare through the conquest of sanitary science and experimental medicine. Popular writers delight to portray the naturalist as a kind of reanimated, antediluvian, or harmless visionary, but what master of romance would have had the ingenuity to conceive of a naturalist's dream as responsible for our greatest engineering feats through discovering the natural history of the mosquito, or that the health and happiness of nations might depend on our knowledge of house-flies, fleas, and even creatures of still more dubious antecedents. This field

is the direct product of our most intensive experimental methods.

For many years,* isolated natural history facts concerning the various species of plants and animals were collected by naturalists. Out of this unorganized material was born the science of ecology, which attempted to systematize and organize natural history data. At first ecology was scarcely more than the mere census-taking of plants, and later of animals, from various environments. Then came the classification of environments on the basis of the dominant forms found in environment. Along with this classification of environments came more or less accurate measurements of the factors composing these habitats, but these were "mostly less" accurate because of the lack of precision instruments which could be used in the field. In this phase of the development of ecology may be mentioned the pioneer work of Warmin, Cowles, and of Shelford.

Only ten or fifteen years ago ecology was struggling to establish itself as a fundamental branch of biology. Today that aim has been reached. It is now considered something more than nature study, or natural history, and has taken its place beside the other biological sciences. It is being introduced more and more in the college and university curricula of the country.

The tendencies in ecology today are toward increasing precision in the measurement of the factors composing the environment. The factors of moisture, current, carbon dioxide, oxygen, and other gases, humidity, rate of evaporation, temperature, are measured with a fair degree of accuracy, where they were not measured at all, by the earlier workers in ecology. Instruments that possessed accuracy and could also be carried into the field have been the crying need. This demand is being met. The thermocouple is being widely used today as an instrument of greater sensitivity and precision than the thermometer. The measurement of light has been baffling, but several instruments are now available for that purpose. Instruments for the measurement of turbidity are now used. Probably the best example of this type

*For the sketch on the development of Ecology I am deeply indebted to Dr. A. M. Holmquist of Chicago Univ.

of exact work in ecology is that of Allee, who recently made a study of the environmental factors in a tropical rain forest at Panama.

There is also a tendency toward quantitative studies of plant and animal distribution as opposed to the purely qualitative census-taking methods of the past.

Huntington has applied ecological data and principles to the distribution of man. Geographers all over the country are doing the same, and today geography is referred to as "human ecology." This seems to me to be a valuable and stimulating application.

Interest is developing in the relation of the individual to the group, and of species to species, particularly of parasites to hosts, and the ecology of parasites.

I have taken but a passing glance at a vast and many-sided subject. I have tried to show that the tide of speculative Zoology is receding, and that experimental methods have taken their rightful place of importance. Through these methods we have attained a truer perspective of the past and present in our studies of the problems of animal life. The destructive criticism through which we have passed has thoroughly cleared the ground for a new constructive era on which we now have entered. All signs of the times indicate that this era will long endure. Guided by the methods of physico-chemical and experimental biology, and avoiding academic discussions of hypotheses that cannot be brought to the test of experimental verification we may hope much for the future.

LONDON ZOO HAS WHITE ELEPHANT.

The only real white elephant in captivity, so far as is known, has just been received at the London Zoo from Rangoon. The royal beast has been given a new house and will be paraded daily for inspection, but, on account of the semi-sacred character invested in white elephants by Burmese tradition, English youngsters will not be allowed to ride him according to the time honored custom of the British Zoo.

The elephant is the property of Dr. Saw Durmay Po Min, president of an organization of the native Christians of Burma, who has agreed to loan the valuable animal for exhibition purposes, a proportion of the receipts going to the association he represents.

"White elephants" are usually no more than pale grey. Such a one was exhibited in the United States by the Barnum and Bailey circus about forty years ago. This animal, however, is said to be almost pure white with the yellowish pink eyes of a true albino.—*Science News.*

CURRICULUM STUDIES ON THE PLACE OF RADIO IN SCHOOL SCIENCE AND INDUSTRIAL ARTS.*

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and

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(Continued from April)

PART 3.—SUGGESTIONS FOR COOPERATIVE CONSTRUCTION WORK IN SCIENCE AND INDUSTRIAL ARTS.

In the two preceding sections of this series pictures of a number of radio cabinets have been shown. In the large cities, from time to time, there is much price cutting on all kinds of radio equipment. For a few dollars one may purchase a cabinet suitable for almost any size of standard panel. Many of these low priced cabinets are soundly built and are well finished. Since this is true, the question may be asked, why should anyone build his own cabinet?

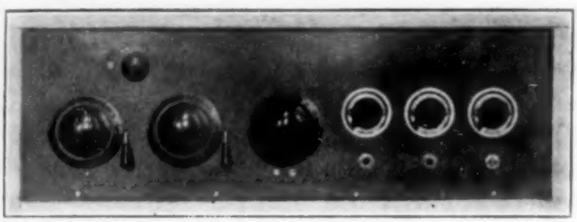

Fig. 52. A School Boy's Cabinet Ready to Stain.

A number of reasons may be given. (1) The school boy enrolled in industrial arts wants to build a cabinet for the radio receiver that he has constructed. (2) The amateur sometimes desires to save his limited funds for essential renewals or new equipment. (3) A person may desire to build a cabinet just for the pleasure to be derived in doing the work. Or one may not find on the market a cabinet to satisfy special needs. (5) The skilled craftsman may build because he can do a better job than is usually done in the factory, or because he wishes to build some special features into his cabinet. To all but the last group the

†Practically all of this work was completed while the author was a member of the staff of the Lincoln School.

suggestions contained in this section may be helpful. *These comments are meant to assist those who have done but little wood working and wood finishing.* The designs and methods of work are, therefore, kept as simple as possible.

XXIII. Choosing Suitable Materials.

The amateur builder usually wants his cabinet to look well in its surroundings. The hand made cabinet will look well if the design is good; if the right kind of wood is used; and if the stain and finish are of the right color. It takes an experienced designer to plan a cabinet that will be Adam, Colonial, or Louis Sixteenth in style. The amateur should not try to do this but he can make a cabinet that will be on friendly terms, at least, with the rest of the furniture.

The first thing to do is to choose suitable wood. The furniture with which the radio cabinet will share a place is probably oak, walnut, or mahogany. If wood like that of the furniture can be found, it may be used. However, oak is hard to work; walnut and mahogany are expensive and are not always easy to get. It may be necessary, therefore, to use some other kind of wood, and for the beginner this is the best thing to do.

The wavy lines or other markings which help one to identify different kinds of wood, and which make one piece of stained wood more beautiful than another are called the grain. Open-grained wood has bold markings, for example ash, oak, or cedar; close-grained wood has more hidden markings, for example gum, soft pine, or poplar. For imitating a close-grained wood, poplar or soft pine may be used. For imitating open-grained wood chestnut, ash, or cedar may be used. All these woods are soft and easy to work.

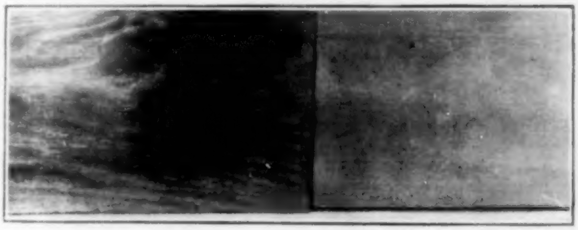

Fig. 53. Open- and Close-Grained Woods.

The wood selected should be well seasoned. Kiln dried wood should be used if it can be obtained. Kiln dried wood has the moisture taken out of it, and is not likely to change its shape by warping or twisting.

If wood can not be obtained from a mill, it may sometimes be

taken from an old piece of furniture. The cabinet shown in figure 54 was made from an old mahogany table that had been broken and stored in a shop for several years. Another cabinet not shown in the illustrations was made of a walnut board found in the attic of an old house. Sometimes wood of fairly good quality can be taken from large packing boxes in which merchandise is shipped to stores. In some instances these boxes are made of wide boards of basswood, poplar, or white pine. If such wood can be found it can be used. Do not try to use wood from boxes made from hard pine or of other hard woods.

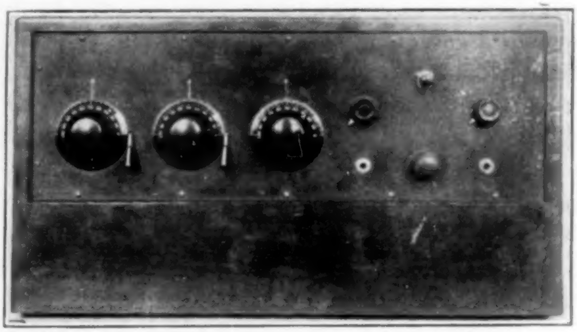

FIG. 54. CABINET MADE FROM AN OLD MAHOGANY TABLE.

XXIV. GETTING OUT THE BILL OF MATERIALS.

Before ordering or sawing out the wood a suitable design

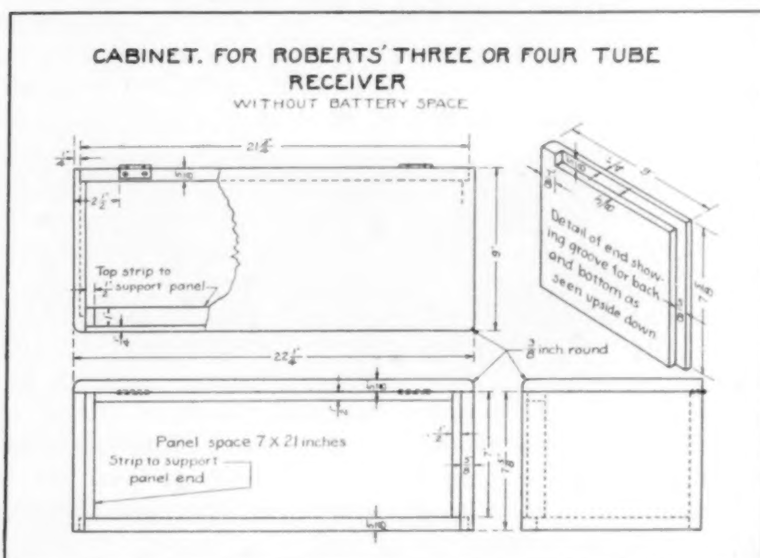

FIG. 55. CABINET WITHOUT BATTERY SPACE.

should be selected or drawn. Two cabinet plans are shown in figures 55 and 56. Figure 55 has no space for batteries; figure 56 has a battery space under the set. These designs can be changed easily to fit a panel of any length. If, for example, the panel is 24 inches long, instead of 21 inches long, as provided for in figure 55, add 3 inches to the lengths given for the botton, top, and back boards. If it is 14 inches long, subtract 7 inches from the lengths given for the bottom, top, and back boards.

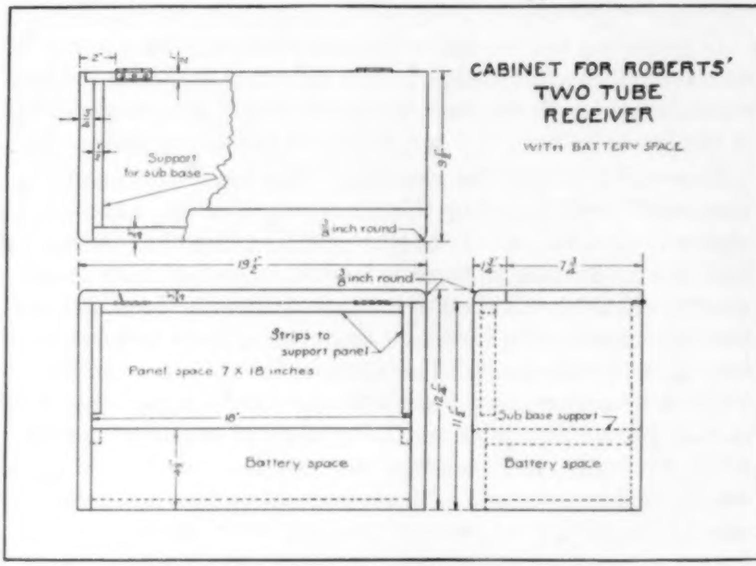

FIG. 56. CABINET WITH BATTERY SPACE.

FIG. 57. BATTERY SPACE UNDER A FOUR-TUBE SET.

XXV. MAKING A BILL FOR LUMBER.

Time will be saved and errors avoided if a lumber bill is prepared in some such form as that shown below. A lumber bill

shows the sizes in the "rough" and is the kind of order one should write if he were getting wood from a mill. Some school shops keep a supply of lumber from which pupils select such boards as they need. In making out the bill of materials it is advisable to leave the short lengths, for example the ends of a cabinet, in one piece until much of the planing has been done. It is easier to plane a board twelve inches long than to plane one six inches long, since the longer board furnishes more surface to help in guiding the plane.

In preparing the bill for lumber attention must be given to the direction of the grain, that is, the direction in which the wood could be split. In the ends the grain should run up and down; in the back, bottom, and top, it should run horizontally.

How thick should the wood be? We have seen cabinets, if they could be dignified by this name, made of wood of all thicknesses, from wood as thin as that used in a cigar box to wood an inch thick. In general, boards less than one-half inch in thickness should not be used. For a panel 14 inches or more in length, this thickness can be increased to 5-8 or ¾ inch without giving the effect of clumsiness. The amateur usually does not have at hand the machines and tools needed to make a perfectly fitted factory joint. This joint may be stronger than one less perfectly made by hand, and therefore the amateur can not be guided wholly by factory made cabinets in deciding how thick the wood should be.

Stock Bill of Materials for Plan Number 1 (Fig. 55).

Number of pieces	Uses	Thickness	Width	Length	Kind of wood
2	sides	⅝"	9"	7⅝"	
1	back	⅝"	7⅝"	21¾"	
1	bottom	⅝"	8⅜"	21¾"	
1	cover	⅝"	9"	22¼"	
2	side strips	½"	1"	7"	
1	top strips	½"	1"	20"	

Materials for Plan Number 2 (Fig. 56).

2	sides	¾"	9½"	11½"
1	front	¾"	4½"	18"
1	coverstrip	¾"	1¾"	19½"
1	cover	¾"	7¾"	19½"
1	bottom	½"	8¼"	18"
1	back	½"	7"	19"
1	back	½"	4½"	19"
2	sub-base supports	½"	1"	8¼"
2	side panel supports	½"	1"	6"
1	top panel supports	½"	1"	17"

XXVI. Methods of Work.

There are several things to be done to each piece of wood used in a radio cabinet. The beginner usually finishes all the work on one piece before starting the next. This is not an efficient method for it takes more time and the work is usually less accurate. A better method is to do the first thing that needs to be done to all the pieces; then do the second thing that needs to be done to all the pieces. To illustrate, one of the broad sides of each board should be planed before planing an edge; then one edge of each of the pieces should be planed.

The cook washes all the dishes, then dries them all, and finally puts them all away. This saves time and needless motions, and suggests a plan which the wood worker will do well to follow.

It will now be necessary to plane all the pieces by hand. Beginners often ask why this must be done. Hold a machine-planed board toward the light. The little hills and hollows which go across the wood, three or four crossing each inch of its length, were made by the machine planer. These hills and hollows show more plainly if the board is stained. They are, therefore, never left on the wood of furniture, or the inside woodwork of houses.

A bench with a vise, a saw, a rule, a try square, and a plane (smoothing plane or jack plane) are needed to prepare the pieces. A board has two broad faces; two edges running lengthwise with the grain; and two ends going across the grain. All these six surfaces should be made perfectly smooth by planing. In these planing operations the exact width, thickness, and length of each piece is obtained, and all corners and edges are made square. This work can be done best in the following order:

(1) Plane one broad surface of each piece as shown in figure

Fig. 58. How to Plane the Broad Side of a Board.

58. Begin on the side that looks the best, and that can be finished with the least amount of work. Test it lengthwise and crosswise with a try square (Fig. 63) to see if it is straight and smooth. Put a pencil check mark on this surface to assist in identifying it later.

(2) Plane one edge of each piece as shown in figure 59. This edge must make a square corner with the broad surface just planed, and it must be smooth and straight. Test it with the try square and with a corner of the plane as in figure 60. Put a pencil check mark on this edge.

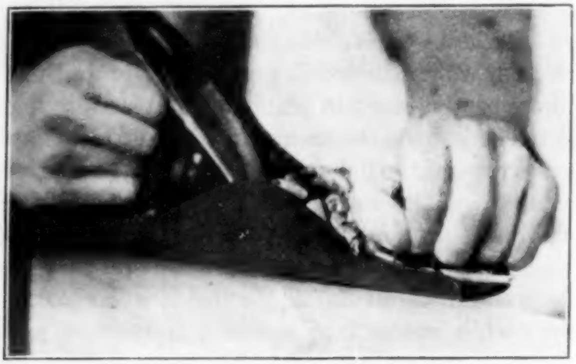

FIG. 59. HOW TO PLANE THE EDGE OF A BOARD.

FIG. 60. TESTING AN EDGE WITH THE PLANE.

(3) Plane one end of each piece. This end must be square to both the broad side and the edge just planed. In testing be sure

to put the handle of the try square against the surfaces just planed, and not on the broad side and the edge (Fig. 61) which have not been planed.

FIG. 61. HOW TO TEST THE END OF THE BOARD.

In planing the ends it is necessary to cut across the grain of the wood. The wood will splinter or split at the far edge if the plane is pushed all the way across. To avoid this splintering the plane should be pushed from each edge toward the center.

(4) Measure the length of the board wanted. Be sure to begin measuring from the end that has been planed. Draw a line with pencil and try square. Then plane and test this end as directed in number three above.

(5) Measure the width near each end. Mark these points with a pencil. Then use a straight yardstick, or some other straight edge to draw the width line through these points. Plane the edge until the line is reached. Be careful to plane just enough. If one piece is made too narrow, it must be thrown away, or all the other pieces made like it. Be careful not to plane too much at one end. The last shaving should be as long and as wide as the edge planed. Stand all the pieces together on edge to see if they are exactly the same height as in figure 62. If the rubber (or bakelite) panel must be planed a little narrower to make it fit the cabinet have the plane very sharp and make very thin cuts. If the panel has been fastened to the baseboard, put the set in the cabinet to hold it. A rule or a folded piece of cardboard may be slipped under the panel to raise it a little higher than the ends of the cabinet while the planing is being done.

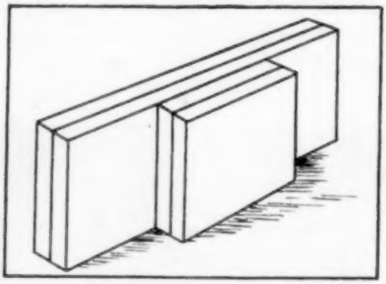

FIG. 62. HOW TO COMPARE THE WIDTHS OF A NUMBER OF BOARDS.

Slip this out from time to time, to see when enough has been planed off to make the panel fit. If the panel has not been attached to the baseboard, put it in the vise to plane it.

(6) Mark the thickness of each piece. Draw a pencil line on both edges and on both ends. Plane the broad side until the lines are reached. This surface should be tested just like the first broad surface was tested, by using the try square as shown in figure 63.

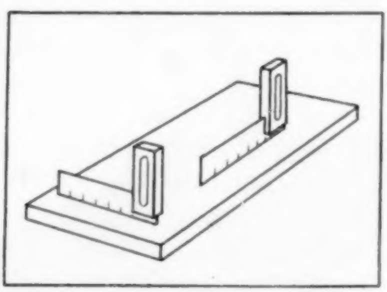

FIG. 63. TESTING THE BROAD SURFACE OF A BOARD WITH A TRY SQUARE.

XXVII. PUTTING THE PIECES TOGETHER.

The corners of cabinets may be fitted together in several ways. The simplest corner joint is made by fastening the end of one piece against the side of another. Wooden boxes are usually put together in this manner.

A stronger and neater corner can be made by cutting an L-shaped notch in the end of one piece, and fitting the other piece into this. (See Fig. 64) The back and bottom of the cabinet shown in figure 52 were put together by this method. More work is required to make a joint of this type, but the improvement in the finished cabinet is worth the extra trouble. If a

corner made in this way is rounded, the appearance is still further improved. Rounded corners are used on the cabinets of several manufacturers and are worthy of imitation.

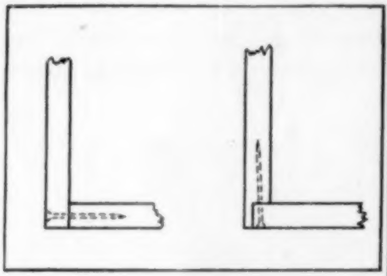

FIG. 64. TWO KINDS OF JOINTS.

FIG. 65. HOW TO BEGIN THE CUT FOR THE HINGE.

XXVIII. HOW TO CUT AN L-SHAPED NOTCH.

Carefully mark out with a pencil the limits of the L-shaped groove. Lay the board flat on the bench and fasten it with a clamp. If no clamp is to be had, lay some waste strips on the bench against the three sides where you will not be cutting. Nail these strips down to the bench to keep the board from sliding. Figures 65 and 66 show how to use the chisel in cutting a

FIG. 66. HOW TO REMOVE THE CHIPS.

notch for a hinge. Cut this L-groove in exactly the same way. Drive the chisel about 1-8 inch deep, and then clean out the chips as shown in figure 66. Make another set of cuts 1-8 inch deep and remove the chips as before. Continue to do this until you have reached the line marked out for depth. Across the ends, the cuts are made in the same way, but the wood is turned around, so the full width of the chisel will be used in the depth cuts. A corner of this kind can also be planed out with a rebate

plane or a power circular saw. Many workers, however, will not have these tools.

XXIX. How to Cut Rounded Corners.

Rounded edges are made with the plane. Tip the plane to one side so it will cut exactly over the corner. Keep cutting in this position until a flat surface has been made on the edge, as shown in figure 67.

Fig. 67. How to Start a Rounded Corner.

This will make two new corners. Next tip the plane more to one side and cut a few shavings from each of these corners. This should make the original corner of the board almost round. It can then be finished with sandpaper. In planing ends the plane should be turned at an angle as shown in figure 68. This will make a smoother cut, and lessen the danger of splintering the wood at the end of the stroke.

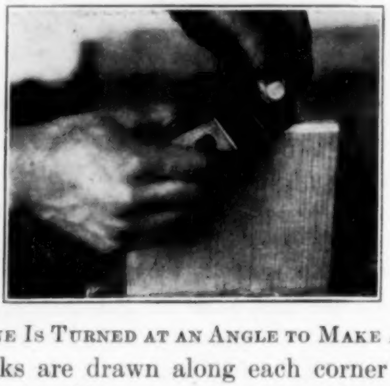

Fig. 68. The Plane Is Turned at an Angle to Make a Smoother Cut.

If pencil marks are drawn along each corner to be rounded before beginning, it will be easier to get uniformity.

If the upright corners of the cabinet have been rounded it will be necessary to round the corner of the top to match them. This cutting can be done by using a chisel as shown in figure 69.

FIG. 69. MAKING A ROUNDED CORNER WITH A CHISEL.

XXX. FASTENING THE PARTS TOGETHER.

Before nailing the parts together, hold all the pieces just as they will be placed when finished to see if everything will fit properly. The two ends should be exactly the same in height and width. The top and bottom should be just right when the panel is in place. Make other tests and correct any misfits before nailing the pieces together. When all parts fit, the joints should be glued and nailed. For half-inch wood use 1½ inch, number 14 brads; for thicker wood a 2 inch, number 12 finishing nail will do. Holes slightly smaller than the finishing nails should be drilled in the piece where the nails start to make them go straight and to keep the wood from splitting. Drive nails through these holes and about 1-8 inch into the second piece of wood, just far enough to be sure they are started in the right place. Then take the piece off and put glue on the end which is to receive the nail. Next replace the nail points in the holes and drive the nails all the way in. By doing this preparatory work much messy work with the glue is avoided, for the glue is very slippery. Unless the pieces are at once kept in position they will slide about and glue will be smeared where it is not wanted. After all the nailing has been done the nails should be driven about $\frac{1}{16}$ inch below the surface of the boards with a nail set or punch.

In figure 55 nail the bottom in first, next the back. In figure

56 nail the sides to the piece that goes under the panel. Then nail the top strip that goes just above the panel. In the design the back is shown as two pieces. The lower piece may be fastened with screws, or it may be hinged to the upper piece. It is desirable to keep the battery space accessible, without having to remove the panel and sub-base.

The holes made by nails should be filled. A good filler may be made by mixing liquid glue with fine sawdust. Work this mixture with a knife blade until all the particles of sawdust are wet with glue. Make this paste as thick as possible. Use it like putty, pressing each nail hole as full as possible. When it has dried each hole should be smoothed with sandpaper. This kind of filler when stained will look like the rest of the wood, and is therefore better than putty for work of this kind. The strips to hold the panel and the baseboard should be now put in place. Use glue and brads.

XXXI. Sandpapering.

The next step is sandpapering. The broad surface should be sanded first. A quarter sheet of number ½ sandpaper should be wrapped around a small block of wood and the sanding strokes made the full length of the board in the direction of the grain. Great care should be taken to go exactly with the grain, as cross scratches will show through stain. The rounded corners should be sanded with number 1 sandpaper followed by number 00. On end grain make the stroke follow the curve; on side grain long strokes lengthwise will complete the corners. Examine each surface near a window where the light is good, to make sure that this work is well done. The beginner is likely to stop with five strokes, when fifty are needed.

XXXII. Fitting Hardware.

(1) *The hinges.* Use a brass or nickeled butt-hinge. The size must be suited to the thickness of the wood used. The width

Fig. 70. Marking Out the Notch for a Hinge.

of the leaf of the hinge should be slightly less than the thickness of the edge across which it is fitted. The knuckle should extend over the edge of the piece on which the hinge fits. Figure 70 shows how to hold the hinge while marking the notch into which the hinge must fit. Use a sharp knife to make the line.

This line will hold the edge of the chisel when finishing the groove for the hinge. The depth of the cut for the butt-hinge should be slightly less than the thickness of the knuckle of the hinge. Half this groove is chiseled from each of the two pieces. See figure 65 and 66 which show how to use the chisel in cutting the groove for the hinges. It will be found best to start the screw holes for the hinges with an awl or small drill. The holes made must be a little smaller than the screws to be used.

(2) *The side hooks.* If side hooks are used to hold the cover in place, put the screw or eye for the hook in first. This is put in the end of the cover. Then place the hook in position holding the cover down, and mark the place for the screw which is to hold the hook. In other words, put the hook on last.

(3) *The folding support.* The folding bracket known as a stay-joint should be put on to hold the cover when open. If this is not done the hinges will soon be pulled loose by the weight of the cover. In deciding just where to fasten the two ends of this support, watch three points; first, that the end of the support to be attached to the cover is set far enough over so it will not hit the end of the cabinet when the cover is closed; second, that the elbow can have room to bend without hitting the back; third that the cover can open (See Fig. 71) a little farther than straight up.

FIG. 71. A FOLDING SUPPORT FOR THE TOP COVER.

XXXIII. PREPARATION FOR STAINING.

When the work described has been completed the cabinet is ready to stain. Before beginning to stain, however, the following important points should receive attention.

(1) Remove all hardware held fast by screws. This will include the folding bracket, side hooks and hinges. Do not mix the screws for the different pieces of hardware. The difficulty of working the staining brush around these metal parts is thus avoided; the metal will be kept clean and bright, and the surface to be stained can more easily be reached. It may seem quite a task to remove all this hardware, so patiently fitted into place. Quite the contrary, it is not difficult to remove and replace hardware held by screws. It is the first fitting that requires care and patience. After this has once been done, the screws will go right back into their places, bringing the hardware back into position without difficulty.

(2) All sharp corners to be found on any part of the cabinet should be slightly rounded. Two or three strokes over the corners with sandpaper will do. This should leave the corners rounded enough to feel smooth to the touch, and to prevent the finish from rubbing off. The sharpest corners on furniture have been treated in this way. Examine the square legs of a chair or a table top to see how this has been done.

FIG. 72. REMOVING A SCRATCH WITH A CABINET SCRAPER.

(3) All surfaces should be wiped clean of sandpaper dust and if no scratches or blemishes appear, the wood is ready to stain.

XXXIV STAINING.

In applying stain or shellac it is important to have a good soft brush. General directions for using the brush are as follows:

(1) Dip the brush into the liquid about one-third the length of the bristles, then wipe off any surplus on the edge of the can.

(2) Apply the liquid near one end of the surface to be covered.

(3) "Brush" in the direction of the grain.

(4) Work towards and out over the end of the board.

(5) The brush strokes should be applied gradually and raised gradually at the close to avoid making "laps."

(6) Work toward the other end.

(7) Edges are usually covered first and adjoining broad surfaces afterward.

(8) The places most difficult to get at should be done first.

(9) Whenever possible work horizontally. This is very important for shellac and varnish, which should be "flowed" on with the least possible working over a second time with the brush.

A good finish may be secured by using stain, filler, and shellac. The stain gives the color and brings out the grain; the filler closes the pores of the wood and makes a hard surface on which other finish may be placed. The shellac protects the stain and can be polished. Since the final appearance of the cabinet will be determined largely by the stain and other finish used, a sample should be prepared in advance.

Plane and sandpaper a piece of wood like that used in the cabinet. Stain, fill, and shellac, and polish this piece carefully. If the final color is not right, other trial pieces may be made. One can not predict results in staining from the stained samples displayed in paint stores, since results are determined by the kind of wood and one's skill in applying the finish. It is a good plan, therefore, to begin making the sample piece several days before the cabinet is ready to stain. Follow the directions given on he container.

There are two kinds of filler,—liquid filler used on close-grained woods and paste filler used on open-grained woods. If paste filler is used it may be mixed with the stain; both stain and filler may then be applied at the same time. After this has dried for a few minutes the surface should be wiped to an even color with cotton waste or a piece of cloth. Be careful to wipe well in corners. Allow this stain to dry 24 hours, then apply a thin coat of white shellac. When this has dried 24 hours, sandpaper it very lightly with number 00 sandpaper. Be careful not to rub through the corners. Apply three more coats of shellac, allowing each to dry, and then sandpaper each before applying the next. The last coat may be polished by using oil and powdered pumice. A piece of cotton waste or cloth is dipped in oil, then in the pumice. The polishing is done with a circular motion. Next wipe the surface dry, and polish it with a piece of chamois or felt. If a very high polish is desired, two or three coats of eggshell varnish should be applied following the coats of shellac. Allow each coat to dry 48 hours. Rub the first coat with curled hair, and the last with pumice and oil. A still higher polish is

obtained by giving a final rubbing with a mixture of oil and pulverized rotten stone. Use soft felt or flannel for applying the final rubbing.

XXXV. A SUMMARY OF WORK IN BUILDING A RADIO CABINET.

A Progress Check List.

1. Find or draw a plan showing the details of construction.
2. Select suitable wood.
3. Write a bill of materials.
4. Saw out the pieces.
5. Plane all pieces to exact size. Follow an orderly procedure.
6. Round the edges with a plane; sides first, then ends.
7. Chisel the round corners.
8. Sandpaper all pieces.
9. Make a trial assembly.
10. Correct misfits if any are found.
11. Nail and glue the pieces together.
12. Drive all nail heads below the surface with a nail set.
13. Fill the nail holes.
14. Prepare a sample of stained wood.
15. Sandpaper all pieces.
16. Put on the hinges.
17. Put on other hardware.
18. Remove all hardware fastened by means of screws.
19. Sandpaper all sharp edges.
20. Wipe all surfaces to remove the sand and dust.
21. Apply the stain.
22. Apply the filler.
23. Apply several coats of shellac.
24. Polish.
25. Replace the hardware.
26. Enjoy the satisfaction of a job well done.

ALGEBRA AND EXCESS-PROFITS TAXES.

By ROBERT MORITZ,

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The time was when algebra was looked upon by many teachers as of little importance outside its function as an instrument for disciplining the youthful mind. With the passing of the doctrine of formal discipline came first the full realization of the importance of algebra as the basic science and universal language, the necessary prerequisite to the successful pursuit of every other quantitative science, more general and far-reaching even than its elder sister, geometry.

H. G. Wells has said somewhere that not only the great body of physical science, but also the facts of financial science and endless social and political problems are only accessible and only thinkable to those who have had a sound training in mathematics. Certain it is that questions arising in business, economic, and governmental relations, depending for their solutions on the processes of algebra, occur in ever increasing numbers. Every teacher must be aware of the innumerable

applications of algebra to intricate questions of finance and insurance and its fundamental importance in the vast field of statistical science. Less well-known may be the fact that algebra is also inseparably tied up with questions of taxation.

A careful analysis of the provisions of the Revenue Acts of 1918 and 1921 relating to Corporation Income Taxes will show that corporation taxes are in general a function of the invested capital while the invested capital is in turn a function of the income tax. We shall show that the exact determination of the tax in special cases requires a knowledge of algebra.[1]

In order to give definiteness to our discussion we will consider a typical special case which arises under the Revenue Act of 1921 and Regulations 62 (1922 edition) relating to this act. We shall determine the income tax for the calendar year 1921 in the case of a domestic corporation from the following data: Capital invested at beginning of year, $1,000,000.00; net income for the year, $400,000.00; dividend paid, July 1, 1921, $200,000.00; dividend paid, Oct. 1, 1921, $200,000.00; required the corporation income tax for the year.

The sections of the *Revenue Act of 1921* and the articles of *Regulations 62* which govern the returns in this case are the following:

Section 230 provides for a tax of ten per cent of the amount of the net income in excess of the credits allowed in Section 236 of the act.

Section 236 provides that for the purpose of the tax imposed in Section 230 there shall be allowed the following credits: (a) A specific credit of $2000 if the net income of the corporation is less than $25,000, with the provision that if the net income is more than $25,000, the tax imposed by Section 230 shall not exceed the tax that would be payable if the $2000 credit were allowed, plus the amount of the net income in excess of $25,000; (b) The amount of any war-profits and excess-profits taxes imposed by Act of Congress for the same taxable year.

Section 301 provides that in addition to the other taxes imposed by the act, there shall be levied a tax equal to the sum of the following: First Bracket. Twenty per cent of the amount of the net income in excess of the excess-profits credits (determined under Section 312) and not in excess of twenty per

[1]It is true that federal agents who administer the tax ignore algebraic methods and proceed instead by a method of successive approximations. The third or fourth approximation will generally give a result sufficiently close for practical purposes. The exact solution which is here presented has the additional advantage of greatly shortening the numerical calculations.

cent of the invested capital. Second Bracket. Forty per cent of the amount of the net income in excess of twenty per cent of the invested capital.

Article 712 (Regulations 62) prescribes the computation of the tax provided under Section 301 for the year 1921 as follows: If the net income is in excess of twenty percent of the invested capital, then under the first bracket the tax is twenty percent of the excess of an amount of net income equal to twenty percent of the invested capital over the excess profits credit, and under the second bracket the tax is forty per cent of the amount of the remaining net income not exhausted under the first bracket. The sum computed under the two brackets is the tax payable. (c) When the full amount of the excess-profits credit is not allowed under the first bracket by reason of the fact that such credit is in excess of twenty percent of the invested capital, the part not so allowed shall be deducted from the amount in the second bracket.

Section 312 provides that the excess-profits credit shall consist of a specific exemption of $3000 plus an amount equal to eight per cent of the invested capital for the taxable year.

Section 326 (d) defines the invested capital for any period as the average (arithmetic average) invested capital for such period.

Article 858 (Regulations 62) provides that for purposes of computing invested capital, a dividend paid after the expiration of the first sixty days of the taxable year will be considered paid out of available net income of the taxable year on the date when it is payable.

Article 857 (1) provides that the available net income at any given date will be determined upon the basis of the same proportion of the net income for the taxable year as the part of the year already elapsed is of the entire year.

Article 857 (2) provides that the available net income at any time will be applied for the following purposes in the order in which they are stated: (a) Accrued federal income and war-profits and excess-profits for the taxable year; (b) Dividends paid after the expiration of the first 60 days of the taxable year.

According to this article accrued taxes take precedence over dividends. Now any dividend payment in excess of the net income available for the purpose at the time the dividend is paid, must be charged against invested capital. Decrease in invested capital will affect the amount of the accrued taxes

which in turn will affect the amount available for payment of dividends, and so on without end.

To obtain a general solution of the problem under consideration we proceed as follows: Let

C = capital and surplus at the beginning of the taxable year,

C' = average invested capital during the year.

I = taxable income during the year,

$D_1, D_2, D_3, \ldots$ = dividends paid at the times $p_1, p_2, p_3, \ldots$ from the beginning of the year,

T_e = excess-profits tax,

a = specific excess-profits tax exemption,

T_n = normal tax,

b = specific normal tax exemption (if any),

$T = T_e + T_n$ = total tax payable for the year.

Then

$\frac{8C'}{100} + a$ = excess-profits tax credits (Section 312).

$\frac{20C'}{100} - \left(\frac{8C'}{100} + a\right) = \frac{3C'}{25} - a$ = income tax payable under first bracket,

$\frac{20}{100}\left(\frac{3C'}{100} - a\right) = \frac{3C' - 25a}{125}$ = tax under first bracket (Section 301).

$I - \frac{20C'}{100}$ = income taxable under second bracket,

$\frac{40}{100}\left(I - \frac{20C'}{100}\right) = \frac{10I - 2C'}{25}$ = tax under second bracket (Section 301).

$T_e = \frac{3C' - 25a}{125} + \frac{10I - 2C'}{25} = \frac{50I - 7C' - 25a}{125}$ (Article 712).

$T_e + b$ = normal tax credits (Section 236).

$I - (T_e + b) = \frac{75I - 7C' - 25a - 125b}{125}$ = income taxable 10% (Section 230).

$$T_n = \frac{75I + 7C' + 25a - 125b}{1250}.$$

$$T = T_e + T_n = \frac{50I - 7C' - 25a}{125} + \frac{75I + 7C' + 25a - 125b}{1250}$$

$$= \frac{575I - 63C' - 225a - 125b}{1250}.$$

Let us next express C′ in terms of the initial capital and the dividends paid during the year.

p_1I is the net income available at the time p_1 (Art. 857, 1).

p_1T is the accrued tax at the time p_1 (Art. 857, b), hence

$p_1(I-T)$ is the sum available for payment of dividends at the time p_1,

$D_1-p_1(I-T)$ is the portion of the dividend D_1 paid out of capital, and since this capital was withdrawn from the business for $1-p_1$ years,

$(1-p_1)[D_1-p_1(I-T)]$ is the reduction in capital due to the payment of D_1. In like manner we find that

$(1-p_2)$ $[D_2-(p_2-p_1)$ $(I-T)]$ is the reduction in capital due to the payment D_2, and

$(1-p_3)[D_3-(p_3-p_2)$ $(I-T)]$ is the reduction in capital due to the payment of D_3, as many such expressions as there are dividend payments which exceed the amount available for payment of dividends at the time the payment is made.

It follows that the average invested capital for the year is $C' = C-(1-p_1)[D_1-p_1(1-T)]-(1-p_2)$ $[D_2-(p_2-p_1)$ $(1-T)]$ — etc.

Substituting this value of C′ in the expression for T above and solving for T we find

$$T = \frac{575I - 225a - 125b - 63C + 63](1-p_1)\ (D_1-p_1I) + (1-p_2)}{1250 - 63[(1-p_1)p_1 + (1-p_1)\ (p_2-p_1) + \text{etc.}]}$$

$$\frac{(D_2-p_2-p_1I) + \text{etc.}]}{}$$

This is the solution of the general case. As an illustration we have in the typical case cited in the outset of this paper,

C = \$1,000,000, I = \$400,000, a = \$3,000, $b = 0$.

D_1 = \$200,000, $p_1 = 181/365$, D_2 = \$200,000, $p_2 = 273/365$,

D_1-p_1I = \$1,643.84, $D_2-(p_2-p_1)I$ = \$99,178.08,

$(1-p_1)$ $(D_1-p_1I)+(1-p_2)$ $(D_2-p_2-p_1I)$ = \$25,826.98,

$(1-p_1)p_1+(1+p_2)$ $(p_2-p_1) = 0.313\ 5147$,

$$T = \frac{575 \times \$400{,}000 - 225 \times \$3{,}000 - 63 \times \$1{,}000{,}000 + 63 \times \$25{,}836.98}{1250 - 63 \times 0.313\ 5147}$$

= \$136,518.83

[1]A dividend which does not exceed the amount available for dividends at the time it is paid must be taken into account at the time the next dividend is paid.

The method of successive approximation employed by revenue officers consists in computing a trial schedule on the assumption that the average invested capital is $1,000,000. The computation yields $133,600 as the tentative amount of the tax. This reduces the average invested capital to $932,268.33.

A second trial schedule is next computed on the assumption that the average invested capital is $932,268.33. This assumption yields $136,473.66 as the amount of the tax, and this in turn reduces the average invested capital to $931,372.58.

A final schedule is now computed with $931,372.58 as the average invested capital. The result is $136,518.12, which is considered the amount of the tax payable for the year.

To obtain the true amount correct to the nearest cent would however require five approximations, each of which involves more computation than the exact solution.

"WHY" AND "HOW."

By F. B. Riggs,

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Whatever criterion of efficiency we choose to assume in placing mathematics in the school curriculum, most teachers are agreed that the major emphasis should be placed on method rather than content. We are more interested, on the whole, in teaching mathematics as a tool rather than in teaching it as an end in itself. The acceptance of this objective of arithmetic has led some of us to overemphasize the importance of manipulation. The headmaster of a large secondary school and a teacher of mathematics told me that he considered it a great waste of time to inflict arithmetical "problems" on boys. Boys coming to him should know how to do anything with figures without worrying about the underlying reasons or why in a particular case one should multiply rather than divide. Boys would have problems enough later.

The problem attitude and approach, however, are results of habits which must be encouraged as early in the child's life as possible. This attitude is perfected by methods of teaching.

Assuming in any one course the content to be constant, we still have much freedom in choice of method.

It is with only two aspects of method that we are here concerned, briefly summarized by "How" and "Why."

There has been a disposition among mathematics teachers not to develop the "Why" attitude of students. In his Dynamic

Psychology (p. 36), Woodworth speaks of two problems one of which ("mechanism") asks how we do a thing, the other ("Drive") what induces us to do it. He says: "Now science has come to regard the question 'Why' with suspicion, and to substitute the question 'How.' Since it has found that the question 'Why' always calls for a further question 'Why' and that no stability or finality is reached in this direction, whereas the answer to the question 'How' is always good as far as it goes, though to be sure, it is seldom if ever complete."

Are we to apply this criterion of science to elementary arithmetic?

Before answering this question let us first exemplify our distinctions by an actual case of teaching in arithmetic.

Teacher: "If 6 apples cost 3 cents, how many apples can I buy for 1 cent?"

Pupil: "2 cents."

Teacher: "Next," or "Wrong," or, "I said how many apples," or, "You had better do the next six for me. A little drill won't hurt you," or, "You can buy for 1 cent ⅓ the number of apples you can buy for 3 cents or one cent is what part of 3 cents, then," etc., and so on.

Now all of these suggestions may lead to the correct answer but does even the last question lead indisputably to correct thinking? The pupil *may* come to one of several dangerous tentative conclusions.

(1) That the answer should be in apples if the question begins with apples.

(2) That he should divide the first by the last.

(3) That he should divide either one by the other and take the most reasonable result.

(4) That he could "do" how much one apple costs but that what one cent "costs" is one too much more for him.

This thinking, while extreme, does bring out some fallacies due to overemphasizing the "How" rather than the "Why." It shows the dangers of drill as a preparation for problems, qua problems. This adherence to drill may be due in part, to a "faculty" psychology through which it is hoped the mind will be made "strong"—strong enough to effect a transfer to any problem. It has been suggested that continual practice of the "How" will make the "Why" come easier later. To some extent this is true. But if we have learned anything from the doctrine of the transfer of training the "Why" can best be learned by studying daily the "Why."

The thinking shown by the typical pupil shows that the right answer is not necessarily accompanied by the right sequence of ideas.

To return to the problem of the 6 apples for 3 cents. How can we develop the "Why" attitude? By reverting to the kindergarten method. Place a pile of 6 apples on one end of the table and a pile of 3 cents on the other end of the table. Explain that one of the conditions of the problem is that these two piles be considered of equal value, that 6 apples cost (are worth) 3 cents and that 3 cents are worth (cost) 6 apples. Then proceed to take a certain part of the apples or cents and ask what part of the cents or apples will have to be taken. Remember that they are the same in regard to value so that if you take say $\frac{1}{3}$ of one you must take a ——? of the other.

The "Why" was once revealed to a young boy by a diagramatic balanced see-saw upon one end of which were assumed two horses and upon the other end, equidistant from the support, were assumed ten corpulent men. These ten men balanced the two horses. They were equal in weight. As the denomination was in pounds we could, in truth, say that ten men were equal to two horses. Now, if one horse jumped off, how many men must jump off to keep the balance? We must be fair! Yes, half the number of men. All right. Now, with a similar diagram, expand the idea of equality to worth and cost, say with oranges and cents—what is fair? Remember we must keep the balance. Then proceed with the pictures of apples and cents and finally with their symbols.

The habit of thus visualizing the process tends toward a better understanding of any "Why" and the "How" follows readily enough.

Sometimes, however, the "Why" attitude is perfected at the expense of the proper regard for the "How." Students may be above the average in reasoning about their problems, but their answers are often incorrect and their failures characterized as "carelessness." "He can do the work correctly if he wants to." Possibly this is true, but we know so little about what a child "wants" sometimes, that it would seem to be more intelligent on the part of the teacher instead of giving him a moral lecture to assume that he wants to find correct answers and guide him in the forming of helpful habits accordingly.

Our opportunity is then to look for "type" errors. Even with students who make all conceivable "careless" errors, there are

always some errors which are more persistent than others. To these we should direct our attention. A single example should suffice to show a somewhat neglected technique for correcting prevalent errors in manipulation.

A child has been found making errors in addition, multiplication and division. Investigation of these errors shows that they are almost all attributable to errors in "carrying." To correct this type of error, it is possible to increase the auditory and visual stimuli of these "carrying" numbers. For instance consider:

```
 379
   8
----
3032
  67
```

The child may begin by establishing the visual images of the "carrying" numbers 7 and 6 by writing these numbers lightly, placed as shown, to facilitate addition, not, as frequently practiced, in the column from which they have been derived, but rather where they will be in line for addition.

As soon as the habit of visualizing these "carrying" numbers is established the actual writing of these helps may be discontinued. The child may then be given the auditory help of emphasizing the carrying number. In the multiplication, 379×8 he should say: "8×9, 72" (silently) "SEVEN" (aloud with emphasis). "8×7, 56 and 7, 63" (silently) "SIX" (aloud with emphasis). "8×3, 24, and 6, 30" (silently).

Experience has shown that if this practice of establishing strong auditory bonds is continued until it becomes a habit, the audible expression of the "carrying" numbers may be discontinued, but the auditory images remain.

The "carrying" numbers then have a double set of strong bonds, auditory and visual, to bear them across the disturbing gaps of time and space.

As the child advances in arithmetic, "type" problems become solved by semi-automatic control, the "WHY" merges into the "HOW" and the "HOW" becomes a process sometimes as easy as brushing his teeth. But until we reach that Utopia, we must give separate recognition and treatment to the "Why" and "How" in the teaching of arithmetic.

IDENTIFICATION OF WIRES IN A CABLE.

By William F. Rigge, S. J.

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For telephone men and others who are accustomed to handle cables with hundreds of wires in them, their identification is mere child's play, as it is done by the color or character of its insulation, its position, or one or more very obvious marks. For these the following problem, or rather mathematical study, has no practical meaning. But for one who is all alone, without any one to help him, who can use only one kind of wire, and who wishes to string a dozen or more in a cable, the mathematical aspect of his work may do much to relieve its mechanical and physical labor. This was the writer's condition many years ago when he put in a private telephone system for 12 stations, each of which could call any other directly. There were therefore 14 wires in the cable, one for each station and two for the battery, and this cable ran to each station. On account of the number of these stations and their distance apart, frequent walking from one to another was foreseen to be fatiguing, so that the first condition in the identification of the wires was that the number of trips between stations was to be a minimum.

The method used was to select one station as the starting point and to tag all its wires from 1 to 14. A dry cell was then attached to Nos. 1 and 2, 1 being plus and 2 minus. Then at the second station, where all the wires were unknown, one wire was connected firmly to one binding post of a detector galvanometer, and a second wire touched to the other binding post. If the needle moved at the first trial, which I think happened only once, the two wires were Nos. 1 and 2, and the direction of the swing showed which was which. If there was no closed circuit, the second wire was bent aside and a third, fourth, and each of the rest taken in turn. If there was no life in any of them, the first wire was evidently neither 1 nor 2. It was then disconnected and bent far aside. There were consequently 13 unsuccessful trials.

A second wire of the possible 13 was then screwed to one end of the galvanometer, and each of the remaining 12 touched in turn to the other end. If the needle refused to move, there were 12 unsuccessful trials, the wire that had been attached to the galvanometer was removed and bent aside, and a third wire connected. This process was repeated until the needle showed a closed circuit. Once, I think, this happened at the very last

possible trial, and several times very near to this last one. Once or twice all the wires were dead, on account, of course, of only one unknown poor contact. The entire operation had then to be repeated from the beginning until a live pair was actually found.

The operator then returned to the first station and connected wires 3 and 4 to the dry cell. At the second station he had then 12 wires to identify. Having identified Nos. 3 and 4, he attached Nos. 5 and 6 to the battery, and so on, identifying two wires at a time, and making in all 7 trips, going and returning, and 77 inter-station round trips for the entire system.

The mathematical question that enlivened this tedious operation was to find out the maximum number of possible trials at any station, in case only the very last was successful, the minimum being, of course, only 7. In testing the first wire in connection with the 13 remaining ones, there would be obviously 13 trials. The second wire would give 12, and so on. So that if n = 14 = total number of wires, and $\underline{n}-1$ = the sum of all the numbers from n − 1 down to 1 included, there would be $\underline{n}-1 = 91$ trials necessary to identify the first pair of wires, in case only the very last was successful.

For the second pair there would be only 12 wires to test. Then N = 12, and $\underline{n}-1 = 66$. In the third pair, n = 10 and $\underline{n}-1 = 45$. For the fourth, fifth, sixth, and seventh pair, there would be 28, 15, 6, 1, trials respectively, or 252 in all.

In the case given n was an even number. When n is odd, the process is the same, but the number of trials is different for each pair. These may be neatly found if we write the series of numbers from 1 to n in one vertical column, and in a parallel one the sums of each number and all those less than it. When n is even, we add the numbers in the second column that are on a level with the odd ones in the first, because we want $\underline{n}-1$, and vice versa when n is odd.

1	1
2	3
3	6
4	10
5	15
6	21
7	28
8	36
9	45
10	55
11	66
12	78
13	91
14	105

When n is odd, there will be finally only one wire left through which no current has yet passed. The number of this wire is obvious by exclusion. It is then left to the judgment of the operator as to whether he will spare himself the trouble of a round trip just for one wire and take his chances on its being in good electrical condition, or actually test it out. The number of round trips is then respectively ½(n − 1) or ½(n + 1).

A STUDY OF THE CONTENT OF THE COURSE IN HIGH SCHOOL PHYSICS, WITH SUGGESTIONS OF NEEDED CHANGES.

By J. M. Hughes

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The method of the study. The following questions, which are concerned with the content of the course in Physics in high school, were answered by one hundred teachers.

First, what physics text are you using?
Second, what pages in the text do you intend to have your pupils omit?
Third, what outside readings do you assign your classes as supplement to the work in the text?
Fourth, what laboratory manual or manuals are you using?

The one hundred teachers from whom answers to these questions were received were distributed over twenty-four states. The sizes of the schools in which they were teaching ranged from thirty to forty-five hundred. The distribution showed a uniform representation of small, medium, and large sized schools.

The answers of the teachers to the four questions gave a basis for studying the content of the course in physics in these high schools. Thus, it was thought that the content of the course could be fairly well determined by finding out four things—what texts were used, to what degree the text was supplemented by other materials, what topics were customarily omitted, and what laboratory manuals were in use.

The texts used. It is doubtful if any other subject in the high school has the subject content represented by so few texts as the subject of physics. Of these one hundred widely distributed and , I believe, representative teachers, nine-four used but three different texts. One text was used by forty-nine of them,—a percentage which agrees with the advertising claims of its publishers.

Customary omissions in the text. Only two teachers out of the one hundred planned to omit any of the topics of their adopted texts. Both expressed the intention of omitting those pages which were concerned with a development of the technical phases of musical scales. The two teachers did not state whether the omissions were prompted by an inability on the part of the teacher to develop the topics in music or by a desire to differentiate values. Whatever the reasons, the omitted pages were so few as to effect little change in the content of the course. Some teachers added that, near the end of the course, a lack of time often caused certain omissions which were not anticipated at

the beginning of the course. So far, however, as intentions may serve as a guide, the content of the course in physics in high school which is contained in the text book seems to remain unchanged because of any plans on the part of teachers to omit any considerable portion of it.

Requirement of outside reading to supplement the text. Some idea of the practices followed by the teachers in supplementing the text may be gained from Table I.

TABLE I

Showing the Practice Followed by 100 High School Teachers of Physics in Supplementing the Content of the Text Book.

Teachers requiring no collateral reading	74
Teachers requring some reading in other than the regular text	15
Teachers requiring the reading of an occasional magazine article	5
Teachers requiring an occasional reference outside the text as the teacher sees fit	3
Teachers having a supplementary list of books with options in choice	2
Teachers requiring a special report which calls for outside reading	1
Teachers making definite requirements in outside readings on the part of all members of the class	0
	100

Almost three-fourths of the teachers required no collateral reading. None made definite requirements of all members of the class. Of twenty-six teachers who did encourage outside reading, fifteen made use of other text books which were similar in content to the one in use by the class. It is evident that the teachers accomplished but little change in the content of the course through the practice of supplementary text book work by collateral reading.

Effect of Laboratory work on content of the course. It is difficult to evaluate the contribution made to the content of the course in physics through the medium of laboratory instruction.

The results of laboratory instruction in the sciences need thorough evaluation, not only from the standpoint of determining content, but from the standpoint of pupil achievement. There was such a wide diversity of practice among the one hundred teachers toward the adoption of physics manuals as to make an attempt at content evaluation futile. Neither the method used here nor the information received is appropriate to such an evaluation. Some information on one aspect of the situation, however, can be gained from a study of Table II.

The practice among teachers in the larger schools of devising their own manuals is evident. The practice among the teachers in smaller schools is to use but one manual. The number of

TABLE II

Frequency of use of Various Physics Laboratory Manuals by 100 Teachers

Author	Name of Manual[1]	Frequency of use
Milliken—Gale—Bishop	Laboratory Physics	38
Manual devised by the teacher		19
Black	A Laboratory Manual in Physics	15
Fuller and Brownlee	Laboratory Exercises	7
Garhart and Chute	A Laboratory Guide	6
Conard	Physics Manual and Laboratory Note Book	4
Good	Laboratory Projects	3
Gorton	Laboratory Manual	3
No manual in use		3
Ackley and McCollister	Laboratory Guide for Physics	2
Davis and Brown	Laboratory Physics	2
Turner and Hersey	Loose Leaf Laboratory Manual	2
Coleman	New Laboratory Manual of Physics	2
Wauchope	Laboratory Manual in Physics	2
Henderson	Laboratory Exercises	1
Hamline	General Physics Experiments	1
Hoadley	Physical Laboratory Handbook	1
Cavanaugh, Westcott & Towning	Physics Laboratory Manual	1
Linebarger	Laboratory Course in Physics	1
Adams	New Physics Laboratory Manual	1
Newman	Laboratory Exercises	1
Number in use		115[2]

manuals in use, however, shows a different situation than was found to exist in the use of adopted texts. Here we find a wide diversity. Whether procedure among the teachers was as multiform as the number of manuals was diverse can only be conjectured. In an evaluation of the content of the physics course we shall have to assume in this study that the work of the laboratory was based upon the text book and that its chief purpose was to add meaning to certain principles developed in the regular text.

The nature of the content of the high school course in physics can, in a fairly accurate way, be determined from an analysis of the three text books found to be most commonly in use, providing the assumption concerning laboratory work be admitted.

Similarity in content of physics texts. A careful line by line analysis of the three text books was made. This analysis revealed a surprising similarity in the materials included in all three texts. This similarity was evident in the general plan of the books, in the amount of emphasis given to various topics, and even in the choice of the experimental and pictorial illustrative materials. The materials of the texts were classified under seventy-three topics. The classifications were then compared.

[1]The names of the manuals are given as reported by the teacher.
[2]Some of the teachers followed the practice of using more than one manual.

The comparison showed seventy topics to be common to all three texts. The choice of topics by the authors of the three books came very near to being one of unanimous agreement. One author included a discussion of curvilinear motion and simple harmonic motion, topics which were not included in the works of the other two On the other hand, this same author did not include a discussion of the absorption of gases by solids and liquids, topics which were found in the other two books. Some minor differences, such as the omitting by one of the texts of the term "ductility," or the failure to define volt in terms of number of lines of force cut per second by a conductor, were present but not at all common. Such dissimilarities were sufficiently rare as to excite notice.

The general similarity of the texts was not limited to naterials alone, but extended to the spatial allotments of these materials.

Similarity in spatial allotment to various materials. It would probably be of insufficient value to justify the inclusion here of a table and chart showing the amount of space, exact and relative, devoted by the authors of the three texts to the seventy-three topics included. The reader may gain some conception of the similarity that does exist, however, through a study of Table III.

TABLE III

Portion of Each Text Devoted to the Printed and Pictorial[3] Development of Major Topics Common to All Three Texts.

Topic	Text	Number of lines	Percentage of space occupied
Mechanics and Heat	Number one	6956	46.9
	Number two	7428	48.6
	Number three	7153	46.2
Magnetism and Electricity	Number one	3887	26.3
	Number two	4294	28.1
	Number three	4210	27.2
Sound	Number one	1248	8.3
	Number two	1116	7.3
	Number three	1245	8.0
Light	Number one	2797	18.7
	Number two	2445	16.0
	Number three	2884	18.6

The similarity in amount of space devoted to the four major topics is present to such degree as to call for no comment.

Other points of Similarity. Many other points of similarity

[3]Pictures here were translated into lines on the basis of space occupied.

could be mentioned. In mechanics and heat, for example, sixty pictorial illustrations are practically identical. Little variation in illustrative material is found in going from one text to another. Under the topic of work, for instance, there will be found invariably the pictures of four members of the pulley family,—the single fixed, movable, combination, and differential. Closely following are the lever, wheel and axle, inclined plane, screw, Jackscrew, windlass, crane, and others of this specie.

Significance of similarities. The similarity of the content of these three texts suggests that the subject of physics in the high school possesses its share of inherited tradition. Studies of the time allotment teachers give to the topics in physics show that, in general, the proportion of space a topic occupies in a physics text is a fairly accurate criterion of the amount of time the teacher will devote to it.

When we recall how this relative emphasis of the topics included in high school physics texts was determined, and when we see how teachers loyally follow this emphasis in their teaching, we begin to question the logic of our traditionally inherited situation.

We have seen changes of course. The names of the texts have been changed. Elements of physics has given way to "practical" physics. But, while the latter name has magic, it has changed the actual content but little. Here and there we find the airplane and the automobile introduced, but only too often we fear they were thrown in for good measure. Instead of being satisfied with the "practical," we become fearful of the superficial. We come to feel, in fact, that the change has not bettered the situation. The testing of the achievement of the pupils at the end of the year shows an astonishing lack of primary responses, either in the field of information or in its application.[4] Many college teachers openly express the opinion that the year of high school physics is practically wasted. They find no indication of a superiority of students with the year of high school physics over those who have had none.

Whatever the cause, there is every indication that the present status of physics teaching in the high schools needs to undergo some change. A study of the situation from any angle seems to indicate that this change must be profound rather than superfical and popular.

[4]An extensive testing program was carried out by the writer in standardizing the Hughes Physics Scales, published by the Public School Publishing Company, Bloomington, Ill.

I ASK THE STUDENT—THE REPORT OF AN INVESTIGATION.

By Philip Q. Freeman,
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Somewhere, we remember reading the statement that "it is a fundamental law of the mind that we remember what interests us and seems of real importance to us." Proceeding on the above theory, we had done everything in our power to make the subject of chemistry interesting—performing lecture table experiments where the points in question were not examined by the student in the laboratory and correlating the practical aspects with the various chemical phenomena. As an illustration—glass was etched with the insignia of the high school by means of hydrofluoric acid vapors and attention was called to the fact that thermometers, graduates, etc., were marked in a similar manner Attention was also called to the fact that since the acid was so active, great care was needed in storing and using it. Despite all this, we found that in answer to a test question to name a practical use for hydrofluoric acid, bleaching was given. Many had never heard of the acid, apparently. Chlorine was named as a gas escaping from soda water and this some weeks after the properties of that gas were discussed as a poison in warfare. There were so many other ridiculous answers that the writer felt that if a test is for the purpose of testing the teacher as well as the pupil, he must be near the verge of failure.

We had read so much about making the subject interesting and we were doing the very best we knew how. We decided to go to the student for criticism and get his viewpoint, since we felt that he was as interested in good grades as we were to have him make them.

The problem of getting him to tell exactly what he thought would best be accomplished, in our judgment, by giving the following list of questions. Each student was especially asked to give his honest opinion by marking down an "X" after the proper statement in such a manner that the teacher could not determine how any individual voted. No names or other writing were asked for, so that recognition of handwriting was out of the question. A student collected the papers and mixed them before handing the ballots to the teacher. Thus each student could feel perfectly free to put down what he thought without fear or favor. (It might be of value to know that this questionnaire was given before the test grades were made known.) We have two classes in chemistry and have appended data show-

ing how the questions were answered. The questions are probably not the best that could be devised for they were formulated rather hurriedly the day after the test.

	Questions	Votes 1st class	Votes 2nd class
1	Chemistry is an interesting study	21	21
	Chemistry is not an interesting study	2	1
2	Chemistry is very difficult	3	5
	Chemistry is moderately difficult	15	17
	Chemistry is easy	5	0
3	I honestly believe that I put a proper amount of time on lesson preparation	10	10
	I honestly believe that I do not	13	12
4	Laboratory work clarifies principles of the text	22	20
	Laboratory work does not do the above	1	2
5	Chemistry seems like a mass of jumbled facts	12	6
	I understand chemical laws and see order and system to the subject	11	16
6	The teacher, in my opinion, is making the work interesting and clear	21	21
	The teacher is not doing the above	2	1
7	I am doing my full share in trying to be interested in the subject and making an effort to understand chemistry	18	21
	I skip over the more difficult parts without trying to master them and read only the easy parts	5	1
8	Chemical literature outside of the text is read when suggested	22	20
	The only chemical literature read is the textbook	1	2

In the examination of these results, some apparent discrepancies came to light. Forty-two out of forty-five found chemistry interesting and yet twenty-five admitted that not a sufficient amount of time was put on lesson preparation. Evidently interest does not beget work. Forty-two out of forty-five thought the teacher made the work clear so as to be understood and yet eighteen found the subject a mass of jumbled facts. We are rather at a loss to account for this unless it is due to forgetfulness. We do not think that under the conditions of the questionnaire that any of the students were trying to win favor with the teacher in number six. It is interesting to note that those who find that the teacher cannot make the work interesting do not take any interest in the subject. Number eight was asked to see what proportion endeavored to work up an interest in chemistry in case they answered number one negatively. Number four shows student opinion on laboratory work. Just how the conditions that number five indicates may be removed is the problem before us. We take it as a criticism indicating lack of drill work, although pressed for time for much of this

kind of work with more than forty laboratory periods a year, an equivalent of two school months.

Our next problem was to get information from the students as to why insufficient time was spent on lesson preparation even though these lessons were interesting. It was suggested to the classes that their reasons be type-written or given in disguised hand-writing and handed in. This was made voluntary, for we felt that to compel everyone to hand in a reason would be incentive to "fake" some. Fourteen were handed in, some of which were worthless as far as specific information was concerned.

Five mentioned lack of time because of heavy outside reading assignments and frequency of written reports required in other courses. One pupil says: "All teachers do not assign work alike and sometimes do not think of a pupil carrying more than that one subject." There is food for thought here. Three pupils mentioned outside activities which absorbed their time and thought and in which they took more interest than in chemistry, interesting as it might be—and it will be a man's sized job to make chemistry surpass them in interest. They are radio, athletics, social functions, music and clubs.

Several students mentioned the fact that the teacher's explanation of the advance lesson produced a tendency for less study. It has been our custom to endeavor to "sell" the advance lesson to the class. If the text described some point or experiment which the student did not do in the laboratory, we performed an experiment to illustrate. Thus, if the text used the word precipitate for the first time, we made some, bringing out the point about them being insoluble in the liquid in which they are formed. Explanations are not always given, the object being to arouse interest and make the subject concrete, but if some student offered something we always "struck while the iron of interest was hot." We have devoted fifteen minutes—sometimes more if occasion seemed to require it—for this purpose. To our surprise this may be a detriment instead of a help. Let us quote two students. "It has been your custom to use much of the period to explain the advance lesson. This is a great help in preparation, but I don't believe it balances the following thought: It is the characteristic of a high school student to study the least possible for a certain grade. Student recitation is not carried on as extensively in your classes as in those of other teachers in the high school. This encourages

pupils to put preparation of other lessons before that of chemistry." The other pupil states, "The explaining is quite a help but the tendency is not to study the lesson. You think you have it and you do for that day but by the next day you forget all you did know." However, we feel it is better to err by going over the advance lesson rather than not to say anything about it. We frequently give unannounced, short written quizzes to compensate for time lost from recitation work to keep students "on the job" but evidently our first student does not think they take the place of regular recitation work.

In regard to radio and other activities, many of us who are now teaching must not forget that we did not have the many distractions and varied interests of the present day while we were in high school. The writer went to an average sized high school not so long ago and yet there were not the many clubs, school papers, complex radio circuits and abundant automobiles in those days. All schools have these conditions in general now and along with them has come a tendency to insist less on home study than previously, so what the student gets must be during study hours in school. Do not understand the writer as decrying the formation of clubs, school papers, debates, etc. Not at all. They are here and they have a place to fill but they subtract just that amount of time from proper lesson preparation unless the student is willing to study outside of school. It seems as if a choice must be made between mastery of fewer points in chemistry, or cover the ground with the idea of mastery as secondary. Results of tests in general seem to indicate the latter.

The ideas expressed in some of the papers led us to formulate one more questionnaire, the general results of which are given below. Since we have no desire to burden the reader with a large number of statistics, suffice it to say that 25 per cent of our chemistry students carry five or more subjects. On laboratory days, these students cannot get more than one study period per day. Nine of the 25 per cent belong to at least one club and are on the staff of the school paper, in music organizations or debate in addition. Some of these students are capable of carrying the load, but it is our opinion that it is too heavy for the most of them to do thorough preparation. School time devoted to clubs ranges from 45 minutes every other week to 135 minutes per week. School time devoted to the paper, debate or music ranges from 15 minutes to 270 minutes per week.

When asked how many students studied at home, 41 signified

that they did. However, it has been our observation that conditions for study are not of the best in many homes.

SUMMARY.

Chemistry is interesting but not studied.

It is not studied because:

The teacher explains the advance lesson.

Of heavy work in other courses.

Of radio, athletics, social functions in and out of school and activities not at all connected with the school.

Of heavy load in regard to the number of subjects carried.

Of large amount of time devoted to extra-curricula activities.

COMMERCIAL PROCESSES IN HIGH SCHOOL CHEMISTRY—A QUALITATIVE ANALYSIS.

BY JOSEPH N. NATHANSON,
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What commercial manufacturing processes involving chemical changes should be taught in high school chemistry? I am not referring to some of the new types of courses, now taught in some high schools, specialized, or practical courses designated by such names as "industrial chemistry," "practical chemistry," "chemistry of everyday life," but to the good old fashioned college preparatory course in chemistry, as most of us know it. With the growing tendency toward making even the stereotyped course of high school chemistry practical and utilitarian, it seems to me that this question becomes more and more pertinent.

That the value of industrial processes and practical applications are recognized by writers of chemistry text books as well as by teachers of the subject is shown by Messrs. J. Cornone, and J. C. Colbert in their article entitled "A Quantitative Analysis of Aims in Teaching High School Chemistry" printed in the February, 1924, issue of SCHOOL SCIENCE AND MATHEMATICS (Vol. XXIV No. 2, pages 168-173.) In this article the writers showed that five of the most widely used text books devote on the average 25.2 percent of their total subject matter to the practical side of chemistry. They also found by the questionnaire methods that about 25.69 percent of teachers' stress is placed on useful application.

The question, then, is not whether or not industrial chemical processes should be taught, but which ones should be taught and which ones should be left out. An examination of five leading chemistry texts reveals over 50 industrial processes

mentioned. In very many cases—just mentioned and nothing more.

The writer attempted to make a qualitative analysis of the 50 or so processes found in the above mentioned texts. An analysis of this kind, or course, is just a matter of opinion, and it is given here only for what it is worth. The writer read through the paragraph of paragraphs dealing with the various processes, and judged them by what, in his opinion, a high school student could gather from the text as to the industrial side of the process in question. On this basis, the writer relatively scored the various processes in each text as shown in the following table:

No.	Process	Black and Conant	Brownlee and Others	McPherson Henderson	Newell	Dull
1	Electrolysis of water	......	C	C	E	D
2	Purification of water	B	......	D	C	B
3	Electrolysis of brime	B	C	D	C	D
4	Bleaching	C	C	D	C	D
5	M'fg of HCL	......	......	D	C	......
6	M'fg of Na and K	D	D	D	C	......
7	Extraction of NaCl	C	C	D	D	C
8	The Soda Processes	C	D	C	D	D
9	Extraction of sulphur	B	C	B	C	B
10	M'fg of Carbon disul.	C	......	C	C	......
11	M'fg of Sulfuric acid	B	C	D	A	B
12	M'fg and use of liquid air	B	......	D	C	B
13	M'fg of ammonia	......	D	D	E	D
14	Refrigeration	B	C	B	C	C
15	M'fg and use of Phosphorous	D	C	C	C	D
16	M'fg of Bromine	......	C	D	D	......
17	M'fg of Iodine	D	C	C	C	D
18	Etching of Glass	D	C	B	C	A
19	Refining of petroleum	C	D	C	C	......
20	M'fg of amorphous carbon	C	D	C	C	......
21	Making artificial diamonds	......	......	D	E	......
22	Chemistry of fuels	B	B	B	B	A
23	Smoke prevention	......	......	C-	......	B
24	M'fg of ammonia	......	D	D	E	D
25	Fire extinguishers	C-	D	C	C	E
26	M'fg of soap	D	C	A	D	C
27	Chem. of explosives	......	D	D	E	D
28	Sugar Industry	C	C	A	D	C
29	Starch Industry	D	......	C	C	D
30	Paper Making	D	......	C	E	A
31	Alcoholic and Acetic ferment	C	E	C	C	D
32	Hydrogenation of vegetable fats	......	......	D	......	......
33	Chem. of Textiles	E	......	C	......	B
34	Fertilizers	C	......	D	......	C
35	Carbide and Cyanamid	......	......	D	C	......

No.	Process	Black and Conant	Brownlee and Others	McPherson Henderson	Newell	Dull
36	Building Materials	B	B	B	B	......
37	Softening of Water	B	C	D	......	C
38	M'fg of Glass	B	B	B	C	A
39	Clay, Cement and Concrete	D	C	C	D	C
40	Metalergy of Al	C	C	B	C	C
41	Metalergy of iron and steel	A	A	A	A	A
42	Metalergy of zinc and uses	D	C	C	D	......
43	Metalergy of lead and uses	C	B	C	C	C
44	Making of blue print	D	C	C	......	......
45	Metalergy of silver	D	......	D	D	......
46	Photography	C	C	C	D	D
47	M'fg of Ink	D	......	C	......	......
48	Plating	D	......	D	D	E
49	Metalergy of Cu	C	C	C	C	C
50	Chem. of foods	C	......	C	B	C

It is very apparent from the above table that processes like the chemistry of iron and steel, chemistry of fuels and the manufacture of glass are considered by text book writers as very important, and are described well, while processes like manufacture of ink, hydrogenation of vegetable oils and manufacture of bromine are agreed by them as being the least important. Processes like the chemistry of food would occupy a middle position.

To supplement the data obtained from the above named texts the writer sent out a list similar to the list given in the table to a number of chemistry teachers. They were asked to read through the list carefully, and judge each process listed independently, scoring each item A, if they considered it essential in high school chemistry, B, if they considered it very important, C, important, D, interesting, and E, not essential at all. Twenty-eight questionnaries were returned. These were tabulated as follows:

The above table shows that not only is there little corrolation between the opinion of text book writers and teachers, but it also shows a very marked diversity of opinion among teachers themselves. The best that could be done was to distribute the various processes according to the "normal distribution curve." Thus 10 percent or 5 processes were placed in group A. These presumably would be the processes classified as "essential" for a high school student to know. 15 percent or 8 processes were placed in group B as "very important"; 50 per cent of 25 processes

Item No.	No. of A's	No. of B's	No. of C's	No. of D's	No. of E's	Concensus of Teacher	Concensus of Texts
1	22	2	4	0	0	A−	D
2	17	6	2	3	0	B+	C
3	9	9	8	2	0	B	C
4	2	13	12	1	0	B−	C+
5	5	7	10	6	0	C	D−
6	1	2	3	5	17	D−	D
7	2	1	17	8	0	C	C−
8	6	3	16	3	0	C+	D+
9	3	4	10	10	1	C	C+
10	0	1	4	8	15	E+	C−
11	12	15	1	0	0	B+	B
12	0	3	13	10	2	C+	C+
13	8	18	2	0	0	B+	E+
14	14	10	2	2	0	A−	C+
15	0	0	9	8	11	D	C−
16	0	0	4	17	5	D	E−
17	0	2	16	10	0	C−	D
18	1	0	6	14	7	D	C+
19	3	15	8	2	0	B−	B−
20	0	8	15	4	1	C+	C−
21	0	0	2	20	6	D−	E−
22	10	12	5	1	0	B+	B+
23	6	2	9	8	3	C	D
24	0	8	12	8	0	C	C−
25	17	4	4	3	0	A−	C−
26	12	10	6	0	0	B+	C
27	0	5	15	0	8	C+	D
28	0	6	16	1	5	C	D−
29	2	5	14	6	1	C	D
30	2	12	6	3	5	B−	D+
31	3	6	14	5	0	C+	D+
32	3	3	10	4	8	C−	E
33	6	4	17	1	0	C+	C−
34	10	18	0	0	0	B+	D
35	0	10	11	3	4	C+	E+
36	4	16	7	1	0	B−	B−
37	0	5	14	6	3	C−	C−
38	1	0	6	14	7	D	B
39	4	7	3	11	3	C−	C−
40	2	15	11	0	0	B	C+
41	20	6	1	1	0	A−	A
42	0	0	8	12	8	D	D
43	1	8	16	3	0	C+	C+
44	0	4	1	19	4	D	D
45	4	6	15	0	3	C+	D−
46	2	4	6	16	0	D+	C−
47	1	8	16	3	0	D+	E
48	7	7	1	11	2	D+	E
49	0	6	18	4	0	C	C
50	18	3	6	0	1	A−	C

in group C as important." 15 percent or 8 items in group D as merely "interesting" and the remaining 4 processes would be classed as "non-essentials." The order of arrangement of the items in each group is indicative of their relative importance as gathered from the data given in this paper.

GROUP A. "ESSENTIAL" PROCESSES. 10 PERCENT OF 5 PROCESSES

Item No.	Processes	Teachers Concensus	Text[5] Books Concensus
1	Chem. of iron and steel	A −	A
22	Chem. of fuels	B +	B
11	Mfg. of sulfuric acid	B +	B
19	Chem. of petroleum	B −	B
36	Building materials	B −	B

GROUP B. "VERY IMPORTANT" PROCESSES, ABOUT 15 PERCENT OR 8 PROCESSES

Item No.	Processes	Teachers Concensus	Text Books Concensus
14	Refrigeration	A	C +
50	Chemistry of food	A −	C
25	Fire extinguishers	A −	C −
2	Purification of water	B +	C
26	Mfg. of soap	B +	C
40	Metallurgy of Al	B	C +
3	Electrolysis of brine	B	C
4	Bleaching	B −	C +

GROUP C. "IMPORTANT" PROCESSES, 50 PERCENT OR 25 ITEMS

Item No.	Processes	Teachers Concensus	Text Books Concensus
1	Electrolysis of water	A −	D
12	Mfg. and uses of liquid air	C +	C +
43	Mfg. and uses of lead comps	C +	C +
9	Extraction of sulfur	C	C −
49	Metallurgy of copper	C	C
20	Mfg. of amorphous carbon	C −	C −
33	Chem. of textiles	C −	C −
7	Extraction of NaCl	C	C −
24	Mfg. of carboeundum	C	C −
37	Softening of water	C −	C −
39	Clay, cement and concrete	C −	C −
30	Paper making	B −	D −
34	Fertilizers	B −	D
38	Mfg. of glass	D	B
8	The soda processes	C −	D −
13	Mfg. of ammonia	B −	E −
31	Alcoholic and acetic ferment	C −	D −
18	Etching glass	D	C −
27	Chem of explosives	C −	D
45	Metallurgy of silver	C −	D −
46	Photography	D −	C −
29	The starch industry	C	D
23	Smoke prevention	C	D
15	Mfg. of phosphorous and uses	D	C −
17	Mfg. of iodine	C −	D

GROUP D. "INTERESTING" PROCESSES, ABOUT 15 PERCENT OR 8 ITEMS

Item No.	Process	Teachers Concensus	Text Books Concensus
5	Mfg. of HCL	C	D –
28	Sugar refining	C	D –
42	Metallurgy of zinc uses	D	D
44	Making of blue prints	D	D
35	Carbide and cyanamid	C –	E +
6	Mfg. of Na and K	D –	D
32	Hydrogenation of vegetable oils	C +	E
10	Mfg. of carbon disulfide	E –	C +

GROUP E. "NON-ESSENTIAL" PROCESS, ABOUT 10 PERCENT OR 4 ITEMS

Item No.	Process	Teachers Concensus	Text Book Concensus
47	Mfg. of ink	D +	E
48	Plating	D +	E
16	Mfg. of Bromine	D	E
21	Making of artificial diamonds	D –	E –

CONCLUSIONS

(1) The writer believes that what is worth teaching at all is worth teaching well. He would, therefore, be in favor of teaching a few of the practical chemical processes well, rather than give the pupil a smattering knowledge of a multitude. It is well, therefore, to decide, at least in a qualitative way, the relative importance of industrial processes, and allot the available time to them in the order of their importance.

(2) The importance of industrial processes in a course of chemistry in the high school is undisputable. The specific processes to teach, is largely a matter of opinion, governed to some extent by local conditions. There are, however, some chemical processes of undoubted national importance and scope. These must be picked out and attention focussed on them. Whether this study is done or not, is again a matter of opinion.

YELLOWSTONE PARK HAS NEW HOT SPRING.

A new hot spring has broken out at Mammoth Hot Springs, where the park headquarters are situated according to a report from Park Naturalist E. J. Sawyer. The new jet comes through a vent about two inches long and three-quarters of an inch across, and is depositing travertine limestone over an area varying from 25 to 35 feet in diameter. It is located on the lower part of the great group of limestone terraces, near the rocky cone known as "Liberty Cap." Due to the soft and crumbling nature of the limestone in the Mammoth Hot Springs formation, there is a good deal of shitfing about in the location of the springs in this place, but there has been no activity in this particular section of the formation for twenty years or more.—*Science News.*

SOME NOTES ON CHEMISTRY PROJECTS.

By O. E. Underhill,

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This year in my chemistry classes I tried a little project teaching. It was only a start, and the plans were not matured due to lack of time, but certain things, to me interesting, were brought out which I thought might prove helpful to others.

I attempt to keep my laboratory work slightly ahead of my recitation. Owing to a combination of circumstances my laboratory work had moved ahead too fast and I wanted something to fill in for about two weeks. This conditions came just about the time we were studying sulphur and its compounds. I jotted down a list of projects, more or less haphazardly, posted them on the bulletin board, announced that others would be added if suggested by the students, and allowed them to choose the ones they wished to work on. They were of several types, some requiring merely the looking up and organizing of a little material, others requiring laboratory work.

The following is a list of the projects as posted.

1. What happens when sulphur dioxide and hydrogen sulphide are mixed? From the results obtained explain what may take place in volcanoes.
2. Make some sulphuric acid by the chamber process.
3. Test unknowns for sulphate, sulphite, and sulphide ions.
4. How do the two oxides of sulphur illustrate the law of multiple proportions?
5. Determine how some bleaching preparations sold for bleaching straw hats acts.
6. Name two acids, and one basic anhydrides. Prepare each and prove that it is an anhydride.
7. Starting with a weighed piece of copper (about ten grams) find out by experiment how much copper sulphate (crystals) can be obtained. Calculate the theoretical result that you should get. What is your percentage yield?
8. Make a report on the sulphite process in paper making.
9. Prepare as a demonstration for the class the "wine to water" trick.
10. Prepare an exhibit showing the allotropic forms of at least three elements.
11. What three gases are sometimes used in refrigerating plants? What property have they in common? Describe the operation of a plant.
12. Prove that amonium hydroxide is a weak base and that hydrogen sulphide is a weak acid.
13. Show that ammonia will burn.
14. Report on rubber and arrange samples into a demonstration.
15. Prepare some good crystals of washing soda.

This last project was added because I had on hand a large quantity of dirty sodium carbonate which had lost most of its water of crystalization. I desired some good crystals for future

use. One of the boys took this as a project and recrystallized it for me.

As may be seen from the list some of the projects were fairly complicated while others (for example number four) required very little more than the consultation of a textbook. Some called for nothing but a written report (for example numbers eight, eleven, and fourteen). Others required laboratory work. Nearly all required some thinking, and the use of methods new to the student.

My first discovery was that very few in the class could look up references on a subject intelligently, and make a report embodying the ideas from several sources. Their idea seemed to be to copy extracts from the reference books. By working individually with these people I helped some of them to get a better idea as to how to use a reference library. A good report on each subject by some one in each division was read in class.

The student who chose project number 2 was made to study the process and think the thing over until he formed the idea himself that he must devise some way to lead the oxides of nitrogen, steam, sulphur dioxide and air into the same place. I then helped him with suggestions as to apparatus. It is usually suggested by the student that he obtain his sulphur dioxide by burning sulphure, in accord with the commercial process. I suggested that he use another method (sulphuric acid and copper) in order to save time, as it would require a little more complicated generator to make the gas by burning the sulphur. I had on hand some fuming nitric acid made by the class of the previous year and I suggested that this be used to furnish the oxides of nitrogen rather than take the time to make them by using sodium nitrate and acid. One could work this out to show the operation of both the Gay-Lussac and Glover towers as is described in Benedict's "Chemical Lecture Experiments" but the time available was too short to allow of that in this case. The one in each division who first completed this project was allowed to give it as a demonstration to the class. (Only a few in each division would be working on any one project, and as I was giving only a limited time to this work, after any project had been presented as a demonstration I required anyone else who might be working on it to start some other. This happened in only one or two cases.) I had them test for the sulphuric acid formed by adding water to the flask representing the chamber, and then adding barium chloride. A precipitate was formed, partly

soluble in hydrochloric acid. From this they drew the conclusion that part of the precipitate was sulphite due to the presence of sulphur dioxide, and part sulphate due to the acid formed. I think that in some cases if sufficient hydrochloric acid had been added very little sulphate would have been found. The rough test is sufficient to satisfy them, however. I intend sometime to work it out accurately and find how much sulphuric acid is formed. The brown fumes of the nitric oxides turn white in the flask (chamber) very satisfactorily and often chamber crystals are formed, thus giving a good opportunity to take up this point if desired.

Project number one was very simple. The two gases were lead into a Wolf bottle or a widemouth bottle with a three hole stopper Sulphur is liberated and deposited on the sides of the bottle. The wording of the project leads the pupil to connect this up somehow with volcanoes. I also have the pupil conjecture as to how the gases might be present in the volcano, if volcanic sulphur may be formed by their action.

In the laboratory experiment on ammonia only two people in a class of fifty noticed that when a lighted taper was brought to the mouth of a bottle of ammonia a flash occurred. They therefore reported that ammonia did not burn. The purpose of project 13 was to correct this impression. The directions in Benedict's book were followed and the burning of ammonia very successfully demonstrated in all divisions.

In project number ten the element started with was sulphur. The boy who first started this tried sealing the different forms of sulphur in vials. It was found that the plastic variety changed. It was suggested to him that perhaps the air had something to do with the change, and sealing in water was tried. This, of course, was not successful and after certain suggested reading, he decided that the temperature was the deciding factor.

Projects three and six require no comment.

Project number five was listed in the hope that some student would bring in one of the sulphite and acid bleaching preparations on the market, and try it out, but no one chose this project.

Several pupils started with number seven and prepared some very good crystals. The amount of copper was too large, however, and the time required to change it to the sulphate and crystalize it was so long that there was not time for the quantitative work.

Number 12 was done in the usual manner by immersing electrodes in series with a lamp, in the solution. The ones giving this demonstration were required to explain fully about weak acids and bases and why the faintly glowing light indicates a weak acid or base.

While this work was not at all completed I feel that it was successful. I think a series of such projects could be planned and worked in throughout the laboratory work. In fact probably a great many teachers are doing just that. Although these do not fit the definition of a project in that they do not "originate in the pupil" they are of a different type from the usual laboratory experiment. I have taught several years but this was the first time I had felt able to try anything of the sort. Perhaps these notes may be helpful to some teacher planning to do some of this sort of laboratory teaching.

Between the time of making these notes and the receipt of the proof two more exercises of this type have been worked out: One the making of a mirror for the first-aid cabinet, and the other, the preparation of an exhibit showing the different stages in the nitration of toluene to make T. N. T. Some very good T. N. T. crystals were obtained.

HIGH SCHOOL SUBJECTS ON VOCATIONAL BASIS.

Pupils in Detroit (Mich.) high schools must hereafter earn the right to pursue the so-called elective studies. To this end, the curriculum has been divided into core and elective subjects. All pupils are required to take the core subjects, which include health, English, social science, general science, general mathematics, and auditorium attendance. All other subjects are elective and are considered vocational or prevocational. Among "prevocational" subjects are higher mathematics, languages, and the specialized sciences, those studies necessary to higher education and leading to the professions.

The purpose of the plan is to throw back upon the pupil himself the reponsibility for making the grades and to obviate the necessity of dividing students into different achievement groups. It is expected that the plan will make of each class a picked group of students doing intensive study in their chosen subject. Every available method of motivation is utilized.

NORMS FOR THE GROUP FOUR TEST.

By Elliot R. Downing,

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In School Science and Mathematics for January, 1920, (XX, p. 77-83), the author reported tentative norms for the Range of Information Test in Science. In a recent number of the same journal (XXVI, p. 142-146) more accurate norms were given for this test based on a much larger number of cases.

In trying this test in conjunction with other forms of tests with which the author was experimenting, tests that covered much the same type of information that the Range of Information Test required, it was apparently shown that the same student would sometimes make quite different scores on two tests of different sorts even when the subject matter in them was very similar. It seemed therefore advisable to make up a composite test of several different types on the supposition that the average grade of a pupil on the several tests in the composite would be a fairer index of his scientific achievement and ability than his grade in any single one.

Moreover the Range of Information Test has been criticized[1] on the grounds that the student is asked to mark those words or phrases he thinks he can define or explain with an "E," but he is only required to define five of them. Thus no complete check is obtained on the entire lot he marks "E." The grade given on the test must depend on the pupil's estimate of his own ability corrected on the basis of the sample lot of terms which he marked "E" and defined. The test is therefore not purely objective. It was desirable to see how the grades given on tests that were completely objective would correlate with those given the same student on the Range of Information Test.

Three other tests were therefore formulated and printed together with the Range of Information Test, as the Group Four Test. In the first there are sixteen groups of names of objects or persons, five in each group, and one of the five is not in the same class as the others. The pupil is asked to cross it out. An example is given as follows:

Petal, stamen, ~~cotyledon~~ pistil, sepal.

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[1]Ruch, G. M., Tests and Measurements in High School Science, School Science and Mathematics, XXIII, p. 885-891.

The word that is to be crossed out in each of the sixteen is:

1. spinal cord	9. neurone
2. turnip	10. DeVries
3. granite	11. potassium hydroxide
4. fat	12. angle worm
5. Milton	13. pine
6. dyke	14. aniline
7. clam	15. petiole
8. bicycle	16. ammeter

The test is scored by counting the number of words which the student has correctly crossed out and multiplying this number by 6¼ to obtain his grade in per cent.

A second test is a true and false test. There are thirty-three items in this test of which numbers 1, 2, 4, 7, 10, 11, 14, 16, 17, 19, 21, 22, 23, 25, 26, 28, 29 and 32 are true; the others are false. The student is asked to leave unmarked the statements he knows nothing about. The test is scored by counting those statements he marks correctly true or wrong and multiplying this number by three, then repeating the product after the decimal point. Thus if the student marks fourteen correctly his score is 42.42 per cent.

To score the Range of Information Test, count the number of words marked "E" by the student and multiply by two to change to per cent. This is the uncorrected score. On the basis of the accuracy of the definitions given for the words or phrases, reduce this uncorrected to the corrected score. Thus, if two of the definitions given by the student are wrong, the corrected score would be three-fifths of the uncorrected. A definition or explanation is considered correct if it shows that the student has the right idea, even if it is crudely expressed.

The fourth test is a problem test. A picture is given of a farm showing conspicuous shadows of trees and other objects. The pupil is asked: 1. Would you think this is a healthy place to live? If not, why not? 2. The sketch is taken from a photograph made at noon, September 20. What direction is the windmill from the house, north, south, east or west? 3. Roughly what is the latitude of this farm? What makes you think so? If question 1 is answered correctly it is scored 10 per cent, question 2, 30 per cent, question 3, 60 per cent. In the latter, if the pupil gives the latitude of the farm correctly but does not give his reason, or if he gives the correct reason but not the right latitude, he is given 30 per cent. The correct answers are as follows:

1. The barn is higher than the well and the house so the refuse will wash down into them, making the place unhealthy.

2. The windmill is south of the house (in the northern hemisphere). The latter is usually taken for granted in the reply.

3. The latitude is 45 degrees north (or south) since the shadows of the trees equal them in length.

When the student has been scored on all four tests in per cent, the per cents are added together and the sum divided by four to get the grade on the Group Four Test. The following table of averages and medians is based on returns from 3201 students in six Chicago and two Toledo high schools:

GRADES ON SCORES ON GROUP FOUR TEST.

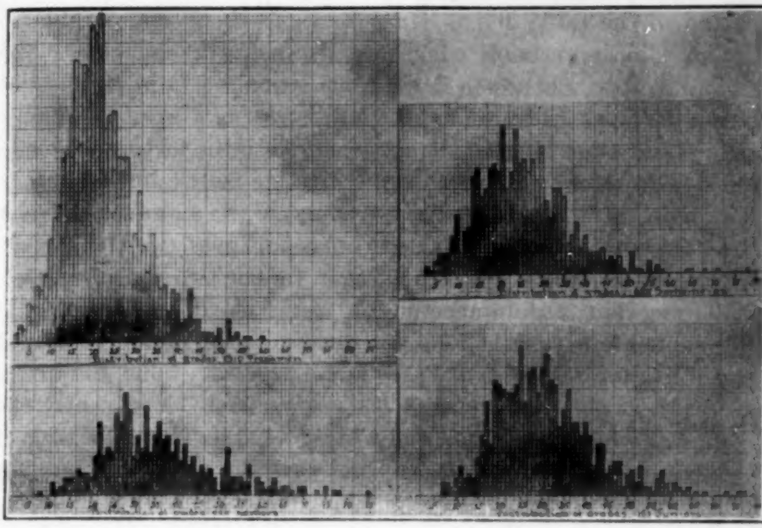
	Freshmen			Sophomores			Juniors			Seniors		
Chi.	No. pupils	Av.	Med.	No. pu'ls	Av.	Med.	No. pu'ls	Av.	Med.	No. pu'ls	Av.	Med.
1	129	16.82	16.08	72	22.06	21.13	99	30.40	30.25	73	33.42	32.00
2	142	19.96	18.58	84	19.49	17.67	78	26.33	25.63	48	38.49	35.00
3	65	19.64	18.75	68	22.27	20.83	101	26.57	26.50	68	34.97	33.37
4	52	17.99	17.87	22	30.61	28.75	29	33.56	35.25	27	33.41	31.00
5	9	20.40	19.00	41	25.18	25.00	71	35.26	32.50	58	38.00	36.67
6	143	17.77	16.75	83	23.38	22.00	50	29.92	27.00	21	36.49	32.00
Toledo												
1	465	27.09	25.02	209	29.87	29.30	241	32.98	31.80	100	39.24	37.30
2	305	23.85	22.60	106	28.20	27.75	82	30.40	27.75	60	34.49	32.66
6 Chicago schools	540	18.41		370	22.13		428	29.72		295	33.77	
2 Toledo schools	770	25.86		315	29.31		323	32.33		160	37.46	
All 8	1310	22.65	21.67	685	25.43	24.97	751	30.84	29.79	455	35.07	33.95

These norms are based on tests given to pupils in the science classes at the end of the first semester in each year of the high school. To determine from these the probable norm for some other time of the year select the norm that is nearest in point of time to the date when the test is given. Add to it or subtract from it, for each month's difference in school year time, one-tenth of the difference between it and the next adjacent norm. Thus the median for freshmen at the end of the first semester is 21.67 per cent, for sophomores 24.97 per cent, a difference of 3.30 per cent. At the end of the second semester of the freshman year the median would be 21.67 per cent plus

$$\frac{\text{five times } 3.3 \text{ per cent}}{10} \text{ which equals } 23.32 \text{ per cent.}$$

For the 1310 freshmen the mean deviation from the median is 7.6, the standard deviation 8.89. For the 685 sophomores the corresponding figures are 8.17 and 10.68; for the 751 juniors, 6.30 and 11.60; for the 455 seniors, 9.99 and 13.46. The increase in the standard deviation from freshmen to seniors means that the students in the high school science classes are progressively

more widely divergent in their scientific knowledge and ability. This will be apparent at a glance from the graphs showing the distribution of the grades of these students in the four years of the high school. Freshmen scores range from 2%-60%, sophomore scores from 3%-78%, juniors' from 7%-82% and seniors' from 8%-85%.



The norms should enable a teacher of science to determine the relative preparation of students in any science class. That these differ widely at the various high school levels is evident. It would seem desirable to group students in different sections in science work when they vary so widely in their ability and preparation, or if that is impossible in the smaller high schools, the teacher with the aid of the test, could early become aware of the differences and concentrate instruction on those pupils most needing his help. It will be noted that this group Four Test is a test in science in general, not a test in general science.

The test can probably be used to advantage also in estimating the scientific ability and achievement of pupils in one school as compared with those in another, possibly, too, the comparative efficiency of the science teaching in the two schools. The test is, however, so long that it is a laborious process to score the papers from a large number of pupils. It is likely that the Five Word Test can be used for this purpose alone quite as advantageously. This matter will be taken up in a later article. No single test however seems to give as accurate a notion of the

individual pupil's knowledge and ability as does the average of all four tests. And to score the papers of a single class is not a tedious matter.

There is a rather striking contrast between the grades secured in the six Chicago high schools and those in the two Toledo high schools, especially in the first. This first school in Toledo reported in the table above is a suburban school, comparable to the six Chicago schools which are also suburban schools. The second Toledo school is a down town school and draws many of its pupils from the more congested district of the city. A possible explanation of the contrast is offered in the fact that Toledo has had in force for some time an effective course in elementary science in the grades. Even if we compare the averages however the difference is marked. The average freshman score in the six Chicago high schools is 18.41 per cent, for the two Toledo schools 25.06 per cent, a difference of 7.45 per cent. The difference in the sophomore year is 7.18 per cent, for the junior year 2.61 per cent, for the senior year 3.69 per cent. The difference decreases in the later years of the high school. Apparently the handicap which falls upon the Chicago pupils from the lack of elementary science in the grades is partially overcome but not completely. Certainly those pupils who drop out of high school in the early years will carry away a good deal more science from their high school course if they have had the elementary science in the grade schools. These conclusions are based on the assumption that the difference is due to the factor named which, although probable, is not demonstrably certain. Whatever the cause is, it is evidently operative before the pupils reach the high school. If it were a matter of superior teaching in the Toledo schools the difference in scores should increase rather than decline from freshman year to senior year.

Calling the Five Word Test number 1, the True and False Test number 2, the Range of Information Test number 3 and the Problem Test number 4, the correlations between the scores on the several tests in the six Chicago high schools is as follows:

Tests	Freshmen		Sophomores		Juniors		Seniors	
	Coef. Cor.	Prob. Error	Coef. Cor.	Prob. Error	Coef. Cor.	Prob. Error	Coef. Cor.	Prob. Error
3 and 1	.2754	.028	.3557	.031	.3807	.029	.4264	.033
3 and 2	.2758	.028	.3370	.031	.3448	.030	.3901	.033
3 and 4	.1187	.029	.3754	.032	.2114	.032	.2851	.036

1 and 2	.2451	.028	.3526	.032	.3676	.030	.3237	.035
1 and 4	.1216	.029	.2078	.033	.2372	.032	.2613	.039
2 and 4	.0125	.030	.1590	.035	.2254	.032	.2496	.036

These correlations were worked out by the product-moment method by Miss Catherine Morgan (Masters Thesis, The University of Chicago, The School of Education, 1924). She scored the papers from these schools, all of which scores have been confirmed by the author.

It will be noted that the correlation of the scores on the Range of Information Test and those on any of the other tests, 1, 2, 4, is on the whole higher than that between the scores on any corresponding two of the latter. The correlations are low throughout but do increase from freshmen to senior years. The lack of correlation confirms the belief that an average of the scores on the four tests is a safer index of a pupil's ability and achievement than is the score on any single test.

WHAT IS A HYPOCOTYL?

By Oran Raber,

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Of all the terms in common use in the teaching of elementary botany none apparently seems to be so unclear or to have so equally a divided number of supporters in favor of some especial nomenclature as the parts of an embryo in general and the word hypocotyl in particular. One school or group of botanists seems to consider the hypocotyl as *everything below the attachment of the cotyledons* in the embryo while another group uses the term for *everything below the cotyledons exclusive of the embryo root,* which makes the term a synonym for the embryo stem in the epigaean type. Still others aren't quite sure what they think.

To show these divisions let us examine some standard books of the last 25 years (mostly of the last ten) and note what we may conclude from "usage." First let us consider those who hold to the opinion that the hypocotyl includes the region below the attachment of the cotyledons exclusive of the root or radicle.

Coulter in the Chicago text (1911) says: "The young sporophyte or embryo at first grows vigorously, usually becoming differentiated at seed maturity into the embryo root (radicle), the embryo stem (hypocotyl), one, two, or more seed leaves (cotyledons), and the embryo shoot (plumule)." This, at least, is clear and definite.

Curtis (1915) states that "The region of the stem above the attachment of the cotyledons is known as the plumule and frequently assumes the form of a minute bud. The region of the stem below the cotyledons is termed the hypocotyl and the root and root-cap appear at its lower end." In a later paragraph one reads: "The region of the stem above the attachment of the cotyledons is known as the epicotyl and frequently appears as a minute bud, the plumule. The region of the stem below the cotyledons, the hypocotyl, terminates in the root." From both these statements it is clear that the embryo root is not a part of the hypocotyl although it is not clear whether the plumule and epicotyl are thought to be exactly synonymous.

The Strasburger text (1921) in speaking of the dicot embryo says: "The latter ultimately develops . . . two large *cotyledons* between which is the rudiment of the apical bud or *plumule*. The region of the stem below the cotyledons is termed the *hypocotyl;* it passes gradually into the main root or *radicle*."

Ganong (1917) in discussing the parts of seeds in general writes: "First in importance is the embryo, which . . . has always a small unjointed stem, the *hypocotyl,* which bears at one end the foundation for a root, at the other the foundation for a bud, and close to the latter one or more 'seed leaves' or *cotyledons*. . . . The bud between the cotyledons is mostly undeveloped in the seed, but in some large, well-developed embryos, it produces visible leaves, in which case it is called the *plumule*." If this is understood correctly the hypocotyl may extend above the cotyledons since it bears the bud on one end and the root on the other.

Holman and Robbins (1924) say: "The organs of the embryo in most seeds are:

1. The plumule—a rudimentary stem, generally termed a bud.
2. The cotyledon (or cotyledons)—seed leaves.
3. The hypocotyl—portion from the attachment of the cotyledons to the upper end of the rudimentary root.
4. The radicle—rudimentary root."

This is a very clear statement of the group which holds that the hypocotyl is that region extending below the cotyledon or cotyledons to the "upper end of the rudimentary root." Hence one must logically conclude that seeds such as the corn and pea which have nothing but roots below the cotyledons have no hypocotyl.

Brown (1925) states that "The embryo consists of a small

undeveloped shoot called the *plumule*, a cylindrical structure known as the *radicle*, which will develop into a root, and one or two large leaves which are the *cotyledons*, or seed leaves."

Here we learn that the hypocotyl isn't found in the seed at all and only several pages later when germination is discussed do we find the term used. Then the need appears for the part of the plant between the root and the cotyledons in a seedling such as the bean. The reader is now told that this is the hypocotyl which is defined for the first time as "the part of the *seedling* (italics mine) between the cotyledon and the root." This introduces a new concept, viz., that the hypocotyl is something which appears in the seedling and is not found in the seed.

Transeau (1924) in describing the castor bean as a seed type says: "The embryo consists of the hypocotyl and two very thin cotyledons, with a small bud between the cotyledons, called the *plumule.* The cotyledons are the first leaf-like organs of the plants. The hypocotyl is the first stem, and the plumule is the first bud. No root is found in the embryo; but when the seed germinates the hypocotyl elongates, and from its basal tip the primary root develops. . . . The plumule grows upward and forms the stem. . . . The parts of the embryo [of the lima-bean] are the same as in the castor bean."

According to this there is no embryo root in the seed but it develops on germination from the tip of the hypocotyl. Here we are told just the reverse of what Brown tells us. According to Transeau the seed has no root below the cotyledons while according to Brown "there ain't nothin' else but" root. This statement of Transeau's as to the absence of any root in the embryo of the seed is quite contrary to the accepted embryological and morphological evidence.

Densmore (1920) in describing the embryo of the dicots states that "The embryo in the seed consists of a stem, or hypocotyl, two cotyledons, and a plumule." In an earlier chapter he says that in the pea seed "Between the cotyledons are found two or three minute leaves, constituting the first bud of the young plantlet, and a stem-like body, the hypocotyl, which bears the cotyledons and the plumule." Neither a root nor epicotyl are mentioned in the text but a series of figures showing the development of the seedling mentions these terms. This is a bit vague, it must be admitted, but apparently Densmore agrees with Transeau that the seed contains no embryo root.

Torrey (1925) is not at all clear on this point. He says: "The young corn . . . develops no hypocotyl" and thus seems to agree in considering the hypocotyl as the embryo stem below the cotyledons but in the bean seed "the pointed cylinder is the hypocotyl" which from the description of its germination would seem to contain the root *Anlage*.

In Bergen and Caldwell's Introduction to Botany (1914) hypocotyl and *caulicle* are given as synonyms. The term caulicle seems to have dropped out of use the past ten years but I believe there is a place for it when properly used.

In the glossary of the 7th edition of Gray's Manual (1908) appears the following definition of radicle: "The portion of the embryo below the cotyledons, more properly called the caulicle." Bergen says the hypocotyl and caulicle are the same and the Manual says the caulicle and radicle are the same. Then if Aristotle is not at fault the caulicle, the radicle, and the hypocotyl are all the same. Obviously it gets worse and worse.

The term caulicle does seem to be an older word for hypocotyl as this latter word is being used by the authors just cited. In Leavitt's Outlines based on Gray's Lessons (1901) we find that "Every well-developed embryo consists essentially of a nascent axis, or stem,—the *caulicle,*—bearing at one end a leaf or leaves, —the *cotyledons,*—while from the other end a root is normally *to be produced.*"

But let us now turn to the first named group who consider everything below the junction of the cotyledons as hypocotyl including root and stem.

Sinnott (1923) says: "In dicotyledonous plants, the embryo is differentiated into three main portions; the *hypocotyl* or primitive stem and root, . . . the two seed-leaves or *cotyledons*, attached to the upper end of the hypocotyl, and the *plumule* or bud, inserted between the cotyledons. . . . In monocotyledonous plants . . . the comparatively small embryo consists of a flat disk, the *scutellum* (which probably represents a single cotyledon) to the face of which are attached an upward-pointing, sheathed *plumule* or bud and a downward-pointing, miniature *root* or *radicle*."

Notice, that according to this conception the hypocotyl exists only in dicot seeds. Monocots have instead a *radicle*. He is at least logical in stating that if hypocotyl includes both stem and root then seeds of the hypogaean type have no hypocotyl.

The Wisconsin text (1924) in speaking of the bean states that "The embryo . . . consists of two large, thick, firm cotyledons closely appressed and enclosing the epicotyl which bears two small, opposite, overlapping leaves. The hypocotyl lies outside the cotyledons and is bent back . . . on the concave edge of the seed." In speaking of the corn grain the same text says: "The greater part of the embryo consists of a large, broad cotyledon whose infolded edges almost completely enclose the epicotyl. . . . Extending in a direction opposite to that of the epicotyl is a small hypocotyl partially surrounded by the large cotyledon and other structures."

Then the monocots *do* have hypocotyls according to this and contrary to Sinnott. The words radicle and plumule do not occur in the Wisconsin text.

Thus much for usage. Now isn't it about time that a science which prides itself upon its complete and accurate terminology should accept and agree upon a logical meaning for so common a term as hypocotyl? The difficulty seems to have been due to (1) a lack of knowledge of the languages from which the terms are derived (2) the confusion of names which denote *position* with those which denote *structural homologies*, and (3) the difficulties of correlating the structures in seeds of the epigaean and hypogaean types.

This matter can be easily straightened out if we accept the following logical classification of the seed parts.

1. hypocotyl—everything below the attachment of the cotyledon or cotyledons. (Gr. *hypo.*—below.)
2. epicotyl—everything above the cotyledons. (Gr. *epi,*—upon or above.)

These two names are thus purely regional and have no relation whatever to the organs which are to develop from them. For these structures let us stick to the following:

1. Radicle—that part which develops into the root. (L. *radix,*—root.)
2. Caulicle—that part which develops into the stem. (L. *caulis*—stem or stalk.)
3. Plumule—that part of the embryo which develops into the leaves with the growing point where they are attached. This is the embryo bud. (L. *plumula*—little feather.)

This then will avoid all confusion. There is no need for new terms but only a need for using the ones we possess correctly. In a seed such as the common bean the hypocotyl includes the

radicle and caulicle, while the epicotyl and plumule are in the same regions. In the pea, the hypocotyl and radicle are the same and the caulicle and plumule lie in the epicotyl. Even a seed like the date then presents no difficulties. This seed contains no epicotyl but the plumule, caulicle, and radicle all arise from the hypocotyl.

Of all the texts mentioned the only one which has not confused the issue is the Wisconsin text which has avoided all use of morphological terms and instead has employed only those of position—hypocotyl and epicotyl. This is the surest way if in doubt, but if the above plan is adhered to, no doubt will be necessary.

We may thus say that the parts of an embryo are the epicotyl, cotyledons, and hypocotyl or, if we wish to show the function of these parts—the plumule, cotyledons, caulicle, and radicle. Let us as botanists try to be clear in our use of these two sets of terms. To mix them only results in the confusions cited above—confusions which constantly multiply instead of diminish.

SUPERCHARGER TO CHANGE AUTO ENGINE DESIGN.

Use of smaller engines in automobiles, only sufficient when operating normally to run the car on a level, but which by the use of a supercharger can be made to give enough power to take them up steep hills, may soon be a possibility, the Society of Automotive Engineers was told at its recent meeting, by G. R. Short, of the General Motors Corporation.

Supercharging, Mr. Short pointed out, consists in increasing the amount of gas and air mixture that the engine normally takes into the cylinders. This may be done by some sort of a pump or compressor to put the extra amount of the mixture into the cylinders, and so get more energy out of them. Such devices have been tried on automobile engines from the first days of the industry, but a great impetus to the use of superchargers has been given in recent years by their use in airplanes. By their aid great altitude records have been possible, whereas otherwise the low pressure of the rarefied air would not permit an engine to work. Racing automobiles also use them to get the greatest power out of their engines.

However, the speaker pointed out, mere increase of pressure in the intake manifold will only result in increase of power when the engine is working at top speed. What is needed, he said, is great power when the engine is working at low speed.

"If this is possible," said Mr. Short, "the supercharger would not only provide greater power from the same displacement of the motor, but also greater flexibility, the lack of which in the present engine is the limiting factor in the utility of the internal-combustion engine. If this can be achieved, it would mean the modification of the transmission, which is the most undesirable part of the automobile."

An engine has been produced recently in Germany, he stated, for marine use, which ordinarily develops 6,400 horsepower, but by use of an electrically driven compressor the power can be increased to 7,800 horsepower, an increase of about 22 per cent.—*Science Service.*

CAN YOU SEE A HOLE?

By Benjamin C. Gruenberg, New York.

The problems submitted by Dr. Webb, namely a definition of a "hole" and a reply to the question whether a hole is visible or invisible, illustrates in a striking manner a serious defect in a great deal of our educational procedure. The problems raised are in no sense problems of *science*. They have to do with refinement in the use of language and clarification in thinking.

If a person said, "I saw a hole in the wall," and were then asked to define a hole, he would feel that consistency required of him a definition in terms that implied visibility. If a person were asked to define a hole and did so in the usual negative terms, and were then asked to say whether a hole were visible or invisible, he would feel that consistency required him to reply in terms of his negative definition. If we recognize that the term *hole* represents an abstract concept, not a concrete object, we may save ourselves a great deal of metaphysical worry.

Perhaps this may be made clear by analogy to something more familiar. What is a cube? Is it visible or invisible? Everybody has seen objects having the shape which we call cube. The object is certainly visible; its shape is recognizable as conforming with our concept *cube*. Yet strictly speaking a cube cannot be seen. To simplify this last statement further, we may take the part of the concept cube which refers to the fact that *a cube has six square sides;* it is utterly impossible to see all of these sides simultaneously.

If we go back now and define hole in terms of *form* or *arrangement* we need no longer be puzzled as to its visibility or its content. We recognize an arrangement of matter, or pattern, even if there are gaps or discontinuities in visible, concrete material. We know the shape or form of the gaps, just as we know the shape or form of any pattern in which, for example, visible units are arranged in squares or hexagons. In practical affairs we make use of doorways, mortices, hatholes, buttonholes and other discontinuities in the material environment—holes. We are capable of becoming aware of such discontinuities, both through the sense of sight, and through other senses, just as we are aware of "rests" in a musical performance through our hearing, even though we cannot hear a silence.

The importance of the puzzle presented by Dr. Webb seems to me to lie in the need of making our elementary school teaching more realistic. There is too much emphasis upon definitions as postulates, with the consequent exaggeration of deductive reasoning. I should like to have teachers of sciences consider the desirability of: (1) avoiding a priori definition, except of incidental terms; (2) making definitions of important items in the subject matter emerge more or less inductively; (3) developing the notion that even definitions are subject to revision with the growth of experience rather than ultimate and authoritative dogmas for the guidance of life and letters.

If we consider these aims, or any of them, desirable, the next question, which I leave with you, is HOW?

METAL WELDING METHODS REVOLUTIONIZED BY NEW INVENTIONS.

Methods of welding metals together will be revolutionized by two new inventions of the research laboratories of the General Electric Company, for after years of search it is now possible to weld so that the fused metal is as strong and as ductile as if it were never in two pieces. Previous methods, using an arc to furnish the intense necessary heat, resulted in the formation of compounds of the metal with oxygen and nitrogen so that the weld was not as strong as the rest of the piece.

As the nitrogen and oxygen which unite with the metal come from the air, in these new processes the air is excluded when the weld is being made by a bath of hydrogen, water gas, wood alcohol vapor, and others which do not easily form metallic compounds.

One of the methods was developed by Dr. Irving Langmuir, assistant director of the Schenectady laboratory, and makes use of what he calls flames of atomic hydrogen, based on a discovery of Dr. R. W. Wood, professor of experimental physics at Johns Hopkins University. Electric currents of twenty amperes and at voltages ranging from 300 to 800 were passed through two tungsten rods so as to form an arc similar to the arc between carbon rods in a street arc light.

By passing a stream of hydrogen gas into the arc from a small tube, an intensely hot flame is produced, because the molecules of hydrogen are broken up by the temperature of the arc into their constituent atoms. As the ordinary form of hydrogen is that of molecules, the atoms almost immediately recombine, but in doing so they liberate great amounts of heat, about half again as much as the oxy-hydrogen flame.

Iron rods an eighth of an inch in diameter melt within a few seconds when held about an inch above the arc, says Dr. Langmuir. Metals even harder to melt than iron, such as tungsten and molybdenum, one of the most refractory substances known, melt with ease. Quartz, however, melts with more difficulty than molybdenum, which Dr. Langmuir suggests as being due to the fact that the metals act as a catalyzer or a substance which speeds up a chemical change.

"The use of hydrogen under these conditions for melting metals has proved to have many advantages," Dr. Langmuir said. "Iron can be melted or welded without contamination by carbon, oxygen or nitrogen. Because of the powerful reducing action of the atomic hydrogen, alloys containing chromium, aluminum, silicon or manganese can be welded without fluxes without surface oxidation. The rapidity with which such metals as iron can be melted seems to exceed that of the oxy-acetylene flame, so that the process promises to be particularly valuable for welding."

The other method of producing ductile welds was developed at the Thomson Research Laboratory of the General Electric Company at Lynn, Mass., by Peter Alexander, independently of Dr. Langmuir's work. The electric arc is passed between the metal to be welded and an iron electrode, and the gaseous atmosphere is supplied in the form of a stream around the arc, so as to keep it entirely away from air. Pure hydrogen, water gas, methanol or wood alcohol vapor, or dry ammonia can be used, as well as a mixture of hydrogen and nitrogen, for it is found that the nitrogen is not harmful unless oxygen is also present. All of these mixtures contain hydrogen, and Dr. Langmuir suggests that this method also depends in part for its efficacy on the disintegration of hydrogen molecules into their atoms.—*Science News*.

NEW CATALOG OF MICROSCOPES AND PROJECTORS.

PROBLEM DEPARTMENT.

CONDUCTED BY C. N. MILLS,

Illinois State Normal University.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor, should have the author's name introducing the problem or solution *as on the following pages.*

The Editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to C. N. Mills, Illinois State Normal University, Normal, Ill.

LATE SOLUTIONS.

915. *Virginia Seidensticker, Hyde Park High School, Chicago, Ill.*

SOLUTIONS OF PROBLEMS.

916. *Proposed by J. Q. McNatt, Canon City, Col.*

Each vertex of a triangle is the center of a circle which is tangent to the other circles. The sides of the triangle are a, b, and c. Compute the radius of the internal circle, and the radius of the external circle, which is tangent to each of the given circles.

I. *Solved by George Sergent, Tampico, Mexico.*

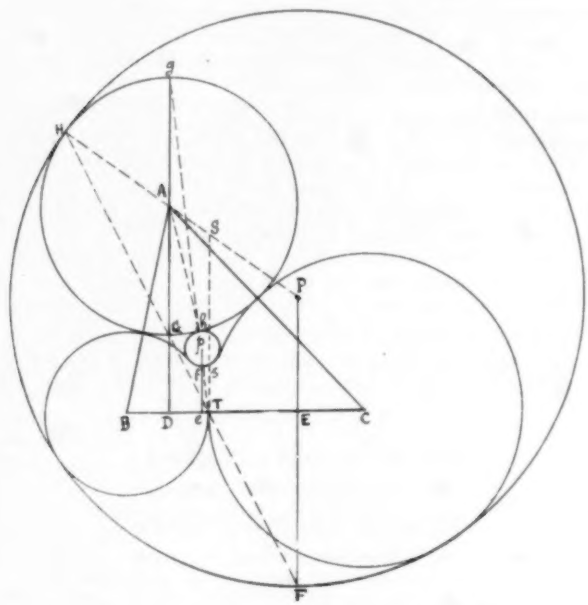
This solution is based on the following definition and theorem.

Definition. The quotient of a circle with relation to a straight line is the ratio of the distance between its center and the line, to its radius.

Theorem. If two circles, A and P, are tangent to one another, are tangent to two circles, B and C, also tangent to one another, the differ-

ence of the quotients of the first two circles with relation to the line of centers, BC, equals 2.

Since this is a problem of computation only, the theorem may be used without proof. It will be shown that the quotient of the external circle must be taken with the negative sign, and the quotient of the internal circle with the positive sign.



Let $r_1 = (s-a)$, $r_2 = (s-b)$, $r_3 = (s-c)$, be the radii of the given circles, A, B, C; r and R the radii, to be computed, of the circles p and P; h_1, h_2, h_3 the altitudes of the given triangle; d_1, d_2, d_3 the distances from the center, p, of the internal circle to the sides a, b, c; and D_1, D_2, D_3 the corresponding distances from the center, P, to the sides of the triangle.

Draw AD $= h_1$, intersecting circle A in G and g, G nearer the base BC. Draw PE $= D_1$, which, produced beyond E, intersects circle P in F, and Pe $= d_1$, intersecting circle p in f. T is the point of contact of circles B and C. The perpendicular at T to BC passes through s, center of external similitude of the circles p and A, and through S, center of internal similitude of the circles P and A. H and h are the points of contact of circle A with circles P and p.

The triangles GAH, TSH, FPH, have the sides AH, SH, PH, on the axis of similitude, SA, and the sides GA, TS, FP, parallel. Hence, the triangles are respectively similar. Likewise, the triangles gAh, Tsh, fph, are similar. It follows that FTGH and fTgh are straight lines.

In the similar triangles TEF and TDG, we have EF $= R-D_1$, and DG $= h_1-r_1$, and the relations

$$\frac{EF}{DG} = \frac{TE}{TD} = \frac{R}{r_1}, \text{ or } \frac{R-D_1}{h_1-r_1} = \frac{R}{r_1},$$

which may be written $$\frac{D_1}{R} = \frac{h_1}{r_1} - 2.$$

Likewise, for the similar triangles Tef and TDg, we have

$$\frac{d_1}{r} = \frac{h_1}{r_1} + 2. \tag{1}$$

For the other sets of similar triangles, we have

$$\frac{d_2}{r} = \frac{h_2}{r_2} + 2 \quad (2), \qquad \text{and} \quad \frac{d_3}{r} = \frac{h_3}{r_3} + 2 \quad (3).$$

Multiplying each of the preceding equations by r, and dividing each equation by its corresponding h, and then adding, we get

$$\frac{d_1}{h_1} + \frac{d_2}{h_2} + \frac{d_3}{h_3} = r\left[\frac{1}{r_1} + \frac{1}{r_2} + \frac{1}{r_3}\right] + 2r\left[\frac{1}{h_1} + \frac{1}{h_2} + \frac{1}{h_3}\right].$$

By a well known theorem, the sum of the ratios in the first member equals 1. In the second member, the sum of the reciprocals of the altitudes equals the reciprocals of the radius of the in-circle. If K is the area, the reciprocal of the in-radius is s/K, or

$$1/r = \sqrt{\frac{s}{(s-a)\ (s-b)\ (s-c)}}.$$

By substitution and rearranging, the value of

$$r = \frac{(s-a)\ (s-b)\ (s-c)}{2\sqrt{s(s-a)\,(s-b)\,(s-c)} \pm \left[(s-a)\,(s-b) + (s-a)\,(s-c) + (s-b)(s-c)\right]}$$

By the same process we derive R, which is the above expression for r using the negative sign.

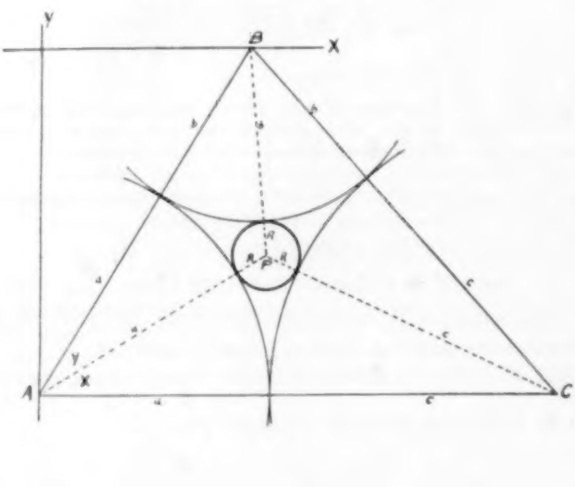
The following solutions submitted by the *Editor* may interest the readers of this Department. For sake of simplicity, the a, b, and c used in the solutions represent the radii of the given circles.

Solution II. Using rectangular coordinates. A, B, and C are the vertices of the given triangle, having the following coordinates

$$\mathrm{A}\left[0,\ \frac{-2\sqrt{abc(a+b+c)}}{a+c}\right],$$

$$\mathrm{B}\left[\frac{a^2+ab+ac-bc}{a+c},\ 0\right],$$

$$\mathrm{C}\left[(a+c),\ \frac{-2\sqrt{abc(a+b+c)}}{a+c}\right].$$



$P(x, y)$ represents the position of the center of the required circle, and its radius is R. k represents the ordinate of A, or C, and h represents the abscissa of B.

$$(AP)^2 = x^2+(y-k)^2 = (a+R)^2. \tag{1}$$
$$(CP)^2 = [x-(a+c)]^2+(y-k)^2 = (c+R)^2. \tag{2}$$
$$(BP)^2 = (x-h)^2+y^2 = (b+R)^2. \tag{3}$$

Solving equations (1) and (2), we get

$$x = \frac{R(a-c)+a(a+c)}{a+c}.$$

Substituting this value of x in (3), we get

$$y = -\frac{2\sqrt{(ab+cR)(bc+aR)}}{a+c}.$$

Substituting the values of x and y in (1), and rearranging we get the following quadratic in R,

$$R^2[(ab+bc+ac)^2-4abc(a+b+c)]-$$
$$R[2abc(ab+ac+bc)(a+c)^2]+abc(a+c)^2 = 0.$$

Solving we get $\quad R = \dfrac{abc}{2\sqrt{abc(a+b+c)}\pm(ab+ac+bc)}.$

The positive sign gives the radius of the inscribed circle, and the negative sign gives the radius of the circumscribed circle. Replacing a by $(s-a)$, b by $(s-b)$ and c by $(s-c)$, the result agrees with the value given in *Solution* I.

Solution III. The general solution is given as far as the algebraic analysis is easily handled. a, b, and c represent the radii of the given circles, and R the radius of the required circle. See Figure for *Solution* II.

$$\cos A = \frac{a^2+ab+ac-bc}{(a+b)(a+c)}.$$

$$\cos X = \frac{a^2+ac+(a-c)R}{(a+c)(a+R)}.$$

$$\cos Y = \frac{a^2+ab+(a-b)R}{(a+b)(a+R)}.$$

$$\sin X = \frac{2\sqrt{acR(a+c+R)}}{(a+c)(a+R)}.$$

$$\sin Y = \frac{2\sqrt{abR(a+b+R)}}{(a+b)(a+R)}.$$

$$\cos(X+Y) = \cos A.$$

Expanding the left member of the above relation, and substituting the values of functions, we get, after simplifying, a biquadratic equation in R. This equation has two factors, one of which is the equation obtained in *Solution* II. The roots of the other equation are imaginary.

Readers interested in this method may check the results by using 3, 4, 5 for a, b, and c. The resulting biquadratic is

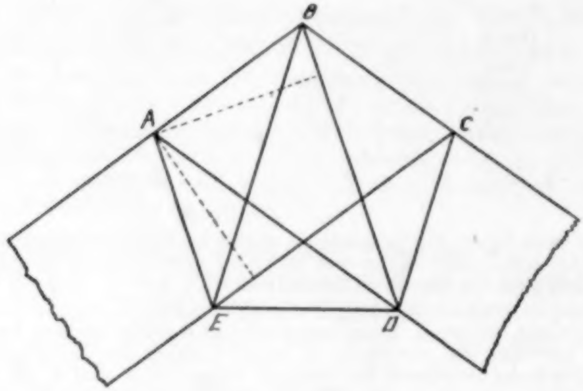
$$671R^4+12350R^3+69575R^2+105000R-90000 = 0,$$
$$\text{or } (671R^2+5640R-3600)(R^2+10R+25) = 0.$$

The values of R for the first factor are .596 and -9.0014.

917. *Proposed by Michael Goldberg, Philadelphia, Pa.*

Tie a flat, close knot in a strip of paper. Prove that a regular pentagon is formed.

Solved by J. Murray Barbour, Ardmore, Pa.



The figure shows the ends of the strip and the knot tied in it. The edges of the strip are parallel and the same distance apart, that is, BC is parallel to AD, CD to BE, AB to EC, and DE to CA. If from A perpendiculars are drawn to CE and BD, equal right triangles are formed, and AE = AB. In like manner, it can be proved that BC = CD, and CD = DE. In several ways it can be proved that ED is equal to any other side. The pentagon ABCDE is equilateral, therefore regular.

Also solved by *Velma Knox, Redlands, Cal.*

918. *Proposed by Orville F. Barcus, Columbus, Ohio.*

To what figure should the "1" in the following number be changed to make the number exactly divisible by 7, 13, and 37:

32,877,728,325,153,257,328,834,456,705?

I. *Solved by Norman Anning, Ann Arbor, Mich.*

Let "1" be replaced by the digit x.

Since $7 \cdot 13 \cdot 37 \cdot 297 = 3367 \cdot 297 = 999{,}999$, it follows that 10^6, 10^{12}, 10^{18}, . . . all leave the remainder 1 when divided by 3367. Consequently if the big number with x in place of 1 is exactly divisible by 3367 the same will be true of the sum of its six-figure periods. Thus $10^5x+1{,}599{,}998$ is exactly divisible by 3367. The same is true for $10^6x+15{,}999{,}980$ and for $15{,}999{,}980+x$. But $3367 \cdot 4752 = 15999984$. So $x = 4$.

$$\begin{array}{r} 456705 \\ 328834 \\ 453257 \\ 728325 \\ 32877 \\ \hline 1999998 \end{array}$$

1999998 divided by 3367 equals 594.

II. *Solved by J. Murray Barbour, Ardmore, Pa.*

If the given number is divisible by 7, 13, and 37, it is divisible by their product 3367. If one divides the given number by 3367 as far as possible and then divides from the unit's digit backward as far as possible it will be found that the two parts of the quotient dovetail. In dividing backward each figure of the quotient is the number that when multiplied by the unit's digit of the divisor will have the same unit's digit that the corresponding minuend has. Near the unknown figure the division is as follows (x represents the unknown figure and the dots non-significant figures):

```
      · · · ·  5077                              7735
3367 )17095x · ·                          · · · x3745 |3367
      16835                                     16835
       260x·                                    ·? 691
       23569                                    10101
         24?··                                  · ·?59
         23569                                  23569
                                                · · ·?9
                                                23569
                                                · · · ·?
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Since the next figure in the quotient of the backward division to the left is zero, the unit's digit of the new minuend must be zero. Working back to x we find that the unknown figure is 4.

III. *Solved by Michael Goldberg, Philadelphia, Pa.*

The number, as given, has a remainder of 6 when divided by 7. The number 10^{17} has the remainder 5 when divided by 7. The equation $6+5n=7m$ must be solved for integral values of m and n ($n \angle 8$). The only solution is $n=3$, $m=3$. The 1 must be increased by 3, that is changed to 4.

The resulting number is divisible by both 13 and 37.

Also solved by *J. S. Georges, University High School, Chicago; R. T. McGregor, Elk Grove, Cal.; E. de la Garza, Jr., Brownsville, Texas; James A. Gardiner, Wilmington, Del.* Two solutions involving congruences, from *Leonard Carlitz*, were received late; and by the *Proposer.*

919. *Proposed by Nathan Altshiller-Court, Norman, Okla.*

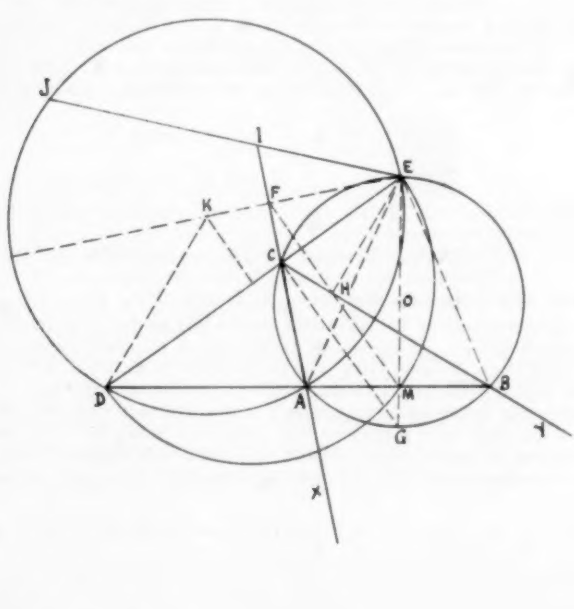
Construct a triangle, given an angle, the external bisector of the angle, and the difference of the sides including the angle.

I. *Solved by George Sergent, Tampico, Mexico.*

Mr. Sergent submits three solutions, and the figure combines all three solutions.—[*Editor.*]

Solution (1). Analysis. Suppose the problem solved, ABC the required triangle, CD $=l$, the given external bisector of the given angle C.

Draw the circumcircle, O, intersecting DC produced in E. From E draw EF $\perp$ to AC produced.



It can be shown that

$$EF = \tfrac{1}{2}(r_a - r_b), \quad \angle CEF = \tfrac{1}{2}C,$$
$$CF = \tfrac{1}{2}(a-b), \quad \angle AEB = C,$$
$$\angle EAB = \angle EBA = 90° - \tfrac{1}{2}C.$$

Also, $\tan \tfrac{1}{2}C = \dfrac{a-b}{r_a - r_b}$. (Problem 878, Oct., 1925)

The diameter through E is $\perp$ AB, and bisects it in M.

$$\angle DAE = 90° + \angle AEM = 90° + \tfrac{1}{2}C.$$

Construct $\angle XCY = C$, and draw the external bisector. From C lay off XC produced $CF = \tfrac{1}{2}(a-b)$. Draw FE $\perp$ to CF, intersecting the external bisector in E. On EC produced, from C, lay off $CD = l$. Then

$$DE = l + CE = l + \tfrac{1}{2}(a-b)\csc \tfrac{1}{2}C.$$

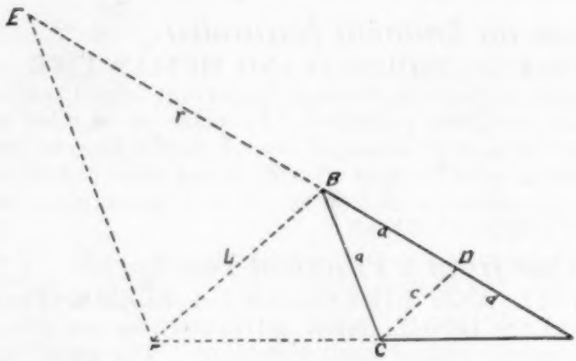
On DE as chord construct an arc capable of the angle $(90° + \tfrac{1}{2}C)$. This arc intersects XC in A. Draw DA, intersecting YC in B. Then ABC is the required triangle.

Solution (2). Construct $\angle XCY = C$. From C lay off on XC produced $CF = \tfrac{1}{2}(a-b)$, and on CY from C, likewise, $CH = \tfrac{1}{2}(a-b)$. Draw perpendiculars FE and HE to CF and CH, respectively; FE and HE intersect in E on the external bisector. Draw EC, produce, and from C lay off $CD = l$. Draw FH and produce. On $ED = l + CE = l + \tfrac{1}{2}(a-b) \csc \tfrac{1}{2}C$, as diameter, describe a semi-circle, intersecting the prolongation of FH in M, the midpoint of AB. Draw DM, which determines A on XC and produce, determining B on YC. Then ABC is the required triangle.

Solution (3). Construct $\angle XCY = C$, and its external bisector $CD = l$. On XC produced lay off $CI = a - b$, and construct the isosceles triangle CEI, with $\angle CEI = C$, as the vertex angle. On EI produced draw $IJ = CD = l$. J is the symmetric of D with respect to the axis EF, perpendicular bisector of CI. The circle through D, E, J, determines A on XC, and DA produced determines B on YC. Then ABC is the required triangle.

II. *Solved by H. R. Scheufler, Culver Military Academy, Culver, Indiana.*

Suppose the required triangle to be ABC with BF the external bisector of the given $\angle ABC$ and AD the given difference of the sides AB and BC. From point F construct FE = BC. Then $\triangle$s FEB and BCD will be isosceles triangles.



The triangle EBF may be constructed knowing L and its base angles. Hence the length r may be determined.

Now in the similar △s FEB and BDC

$$L : c = r : a.$$

Also in the similar △s ABF and ADC

$$L : c = a + d : d.$$

Therefore:

$$a + d : d = r : a.$$
$$a^2 + ad = dr.$$
$$a^2 + ad - dr = 0.$$

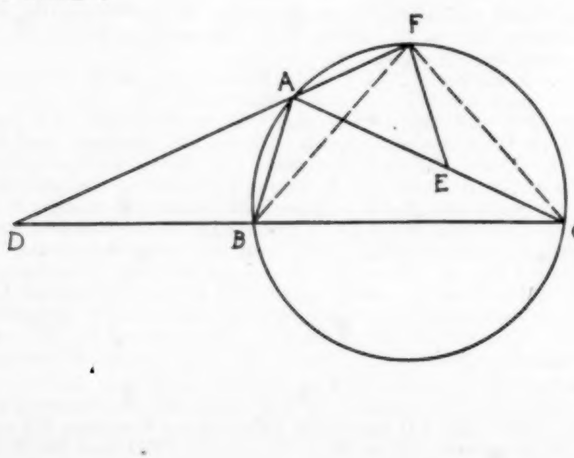
Solving, $$a = \frac{-d \pm \sqrt{d^2+4dr}}{2} = \frac{-d}{2} \pm \frac{\sqrt{d(d+4r)}}{2}.$$

We can construct "a" for we know d and r. That is, construct the mean proportional between d and $(d+4r)$ and bisect it. Adding that to $\frac{-d}{2}$ we get the value of "a." Knowing "a" we can construct the triangle ABC with one side $(a+d)$ another side "a" and the given included angle ABC.

The negative value of "a" would have no meaning geometrically.

III. *Solved by Michael Goldberg, Phila., Pa.*

Construct the given angle BAC, and AD the external bisector. On AC lay off AE equal to the given difference of the two included sides. Construct EF such that ∠AEF = ∠DAB. Produce DA to intersect EF in F. Draw an arc such that AD subtends an angle equal to ∠DAB and cutting AC in point C. Draw DC cutting AB in B. Then triangle ABC is the required triangle,



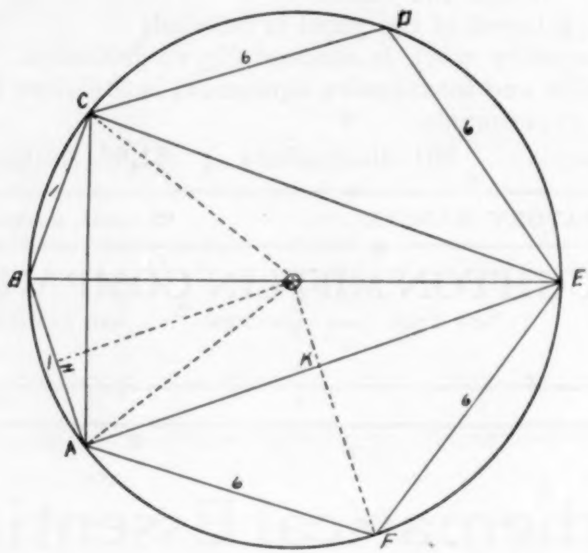
Proof: Draw BF and FC. Since angles BAF and FCB are supplementary the quadrilateral BAFC is cyclic. Therefore $\angle FBC = \angle FAC = \angle DAB = \angle FCB$ and $FB = FC$. The triangles FAB and FEC are equal since $AF = EF$, $FB = FC$, and $\angle FEC = \angle FAB$. Therefore $AB = EC$.

Also solved by *Leonard Carlitz*, Philadelphia, Pa.; and by the *Proposer*. The solutions by the *Proposer* will appear later.

920. *Selected. For High School Pupils.*

In a circle of radius x is inscribed a convex hexagon whose sides are 6,6,6,6,1,1. Find the value of x.

I. *Solved by Radford Barton, Oak Park, Ill.*



By studying the figure, the following statements are easily obtained. OH is the apothem to the side $AB = 1$, and AK is $\perp$ to OF.

$$4\angle AOH + 4\angle AOK = 360°.$$

$$\angle AOH + \angle AOK = 90°.$$

AKOH is a rectangle, since the opposite sides are parallel, and the angles right angles. Let $x = R$.

$$OH = AK = \sqrt{R^2 - \tfrac{1}{4}}.$$

$$KF = R - \tfrac{1}{2}.$$

$$AK^2 + KF^2 = 36.$$

$$(R - \tfrac{1}{2})^2 + (\sqrt{R^2 - \tfrac{1}{4}})^2 = 36.$$

$$2R^2 - R - 36 = 0.$$

Therefore $R = -4$, or $9/2$.

Hence, the radius of the circle is $4\tfrac{1}{2}$.

II. *Solved by the Editor.*

The *Editor* submits the following solution, thinking that it may be of some interest, since the famous *Ptolemy's Theorem* is used. *Theorem*: For any inscribed quadrilateral the sum of the products of the opposite sides is equal to the product of the diagonals.

For the Figure of *Solution I*, the following statements are easily obtained:

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$$AE = CE = \frac{12\sqrt{R^2-9}}{R} \qquad AC = \frac{\sqrt{4R^2-1}}{R}.$$

For the quadrilateral ABCE we have

$$AB \cdot CE + BC \cdot AE = BE \cdot AC.$$

Substituting the values of the line segments gives

$$\frac{24\sqrt{R^2-9}}{R} = \frac{2R\sqrt{4R^2-1}}{R}.$$

Simplifying this equation gives

$$4R^4 - 145R^2 + 1296 = 0,$$

which has the solutions ± 4, and $\pm 9/2$.

Since the circumference of the circle must be greater than the perimeter of the hexagon, 9/2 is the required value of R.

Also solved by *Byron Wittl, Miami, Florida.*

PROBLEMS FOR SOLUTION.

931. *Proposed by R. T. McGregor, Elk Grove, Cal.*

$$\sin A + \cos A + \tan A + \cot A + \sec A + \operatorname{cosec} A = 1.$$

What is the angle A satisfying this condition?

932. *Proposed by Nathan Altshiller-Court, Norman, Okla.*

The perpendiculars from the orthocenter of a triangle upon the medians meet the corresponding sides of the triangle in three collinear points. The line through the points is perpendicular to the *Euler line* of the triangle.

933. *Proposed by Norman Anning, Ann Arbor, Mich.*

Find integral edges for a tetrahedron all of whose faces are right triangles.

934. *Proposed by George Sergent, Tampico, Mexico.*

Given the feet of the perpendiculars dropped from the intersection of the diagonals of a quadrilateral to the sides; construct the quadrilateral.

935. *For High School Students. Proposed by Ivar Highberg, North Central High School, Spokane, Wash.*

To determine the distance between two inaccessible points A and B, two points C and D were taken, and the following measurements were made: (ABCD represents the order of the letters) DC = 850 feet; $\angle ADB = 60°$; $\angle BDC = 30°$; $\angle ACD = 30°$; $\angle ACB = 90°$. Compute AB without the use of trigonometry.

SCIENCE QUESTIONS.

Conducted by Franklin T. Jones

The White Motor Company, Cleveland, Ohio.

To Readers of School Science and Mathematics:

The EDITOR of this Department has been traveling around the country in the discharge of his duties in such a way that he has not been able to prepare material for SCIENCE QUESTIONS. The subject has often been on his mind and he has repeatedly wondered whether or not this department as conducted has been missed. He would welcome a real "calling-down" by readers of SCHOOL SCIENCE on the short-comings of the department. He would also like to hear from readers as to what they would like to have discussed.

The question often arises as to how much the teaching of physics, or chemistry, or even general science differs from the teaching of ten, fifteen, or twenty years ago.

What, if any, advances have been made in *method* of teaching?

Do the teachers of the present time *handle* their boys and girls better or worse? (*Handle* means *manage* in such a way as to obtain favorable reactions from the students.)

Back numbers of School Science, School Mathematics, and School Science and Mathematics may be had for 35 cents a single copy. The Mathematical Supplements for 20 cents a copy. In sets, the prices are, postpaid:

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In what respects is subject matter better or worse?
Do school authorities show any enthusiasm for science teaching?
How can science teaching be made more efficient *and* more effective?
As a suggestion, write a friendly letter to the Editor, tell him his failings, make suggestions for improvement. Who knows but what it may help him or someone else to get somewhere he wants to go!
Thanks! *Do it now!*
You are always invited to propose questions for solution or discussion.
Examination papers are always interesting. Send them in.
Please address all communications to Franklin T. Jones, 10109 Wilbur Ave., S. E., Cleveland, Ohio.
The following letter was recently referred to the Editor by the EDITOR of S. S. & M:

UNIVERSITY OF COLORADO
Boulder, Colorado
Department of Physics

Mar. 22, 1926.

Mr. Charles H. Smith,
Chicago, Ill.
Dear Sir:
Recently I reproduced on the mimeograph an examination paper in physics written by a high school student. I sent copies of this examination to quite a few high school teachers of physics in our larger city high schools, with the request that they grade them. The variation in grades on the same paper was startling—31 to 80. And on a given question the grade ranged from 0 to 10.
I am enclosing copies of the examination and grades in the hope that mention of it in your publication might prove of interest to the remainder of your readers.

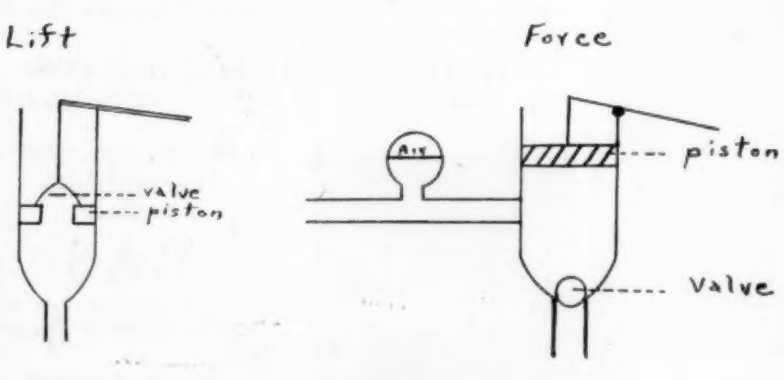
Very truly yours,
J. M. BLAIR.

PHYSICS A, JAN. 1925.

1. (a) *State Pascal's Law and Archimedes' Principle. Uses?*
Pressure placed on a liquid is transmitted undiminished to every portion of the surface of that liquid. Use of this is Hydraulic Press. Archimedes' Prin. states that a solid immersed in a liquid is lifted up by a force equal to the displaced liquid.
(b) *How long is a brass rod of 1 cm. diam. if it weighs 1000 grams and the density of brass is 8.5?*

$$D = \frac{M}{v} \qquad 8.5 = \frac{1000}{x} \qquad \begin{aligned} 8.5x &= 1000 \\ x &= 117.64 \text{ vol.} \end{aligned}$$

II. *Diagram and label parts of lift and force pump.*



III. (a) *State Boyle's Law.*

The pressure of gas at a given constant temp. is inversely proportional to the volume.

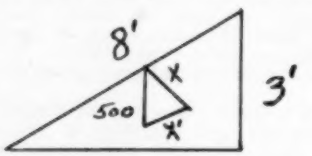
(b) *Find the density of air in a tank under a pressure of 180 pounds. The density of air at atmospheric pressure is .0013.*

$$180 \div 15 = 12;\ \ 12 \times .0013 = .0156 \text{press.}$$

IV. (a) *Explain: resultant of forces, component of force.*

Resultant is that forces which will produce the same effect upon an object as the jointed action of two other forces. Component force is a force which acting with a given force is effectively equal to a force in a given direction.

(b) *A 500 lb. bbl. is pushed up a skid 8 ft. long to a platform 3 ft. high Find the force tending to break the skid.*



$8 : 500 = 3 : x$

$x = 187.5$

$x_1^2 = 500^2 - 187.5^2$

$x_1 = 463.51$ force to break

V. *State Newton's Laws of motion.*

(1) This is the law of inertia.

(2) The rate of momentum of change that takes place is directly proportional to the force acting and the change takes place in the direction in which the force acts.

(3) To every action there is an equal force of action in the opposite direction.

VI. *Show that F equals MA. Illustrate this by an example.*

$F = \dfrac{Mv}{t}$ and we know from formula $v = at$ that $F = a$. Therefore $F = MA$.

VII. *Name seven simple machines and give formula for the mechanical advantage of each.*

(1) levers $\dfrac{De}{Dr}$ (2) Wheel and axle $\dfrac{Re}{e} = \dfrac{Rw}{Ra}$ (3) incline plane $\dfrac{L}{s}$

(4) screw $\dfrac{2\pi l}{d}$ (5) train of gears $\dfrac{s}{s}$ (6) worm gear $\dfrac{n\,l}{r}$

(7) pulley (no. of strands)

VIII. *A car going 20 mph is brought to a stop in 1 min. what is the acceleration?*

$$\frac{20 \times 5280}{60} = 1760$$

IX. *Explain: calorie, B. T. U., specific heat and mech. equivalent.*

A calorie is the metric unit of heat and is the amount required to raise one gram of water one degree.

BTU is the British Thermal Unit. It is the amount of heat required to heat one pound of water one degree F.

Specific heat is the amount of heat required to raise the substance one degree C.

Mechanical equivalent of heat is 4.18×10^7 ergs.

X. *Explain: heat of fusion, heat of vaporization.*

What use can be made of these facts?

Heat of fusion is the number of calories of heat taken up when ice is melted without change in temperature.

Heat of fusion is used in refrigerators, also by putting large vessels of water in fruit cellars one can keep the fruit from freezing.

Heat of vaporization is the number of calories of heat taken up when water vaporizes. It is used in furnaces.

MARKINGS ON PAPER BY EIGHTEEN DIFFERENT TEACHERS

Question No.	Teacher No.																			Med.
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
1	7½	6⅔	10	4	3¼	5	7½	1	3	3	4	7	5	5	6	6	5	7	5	5
2	10	10	5	5	8	7	5	0	5	3	8	8	5	5	7	7½	6	6	7	6
3	10	10	5	6	10	8	9	10	8	10	10	10	9	9	9	10	6½	9	10	9
4	5	3⅓	7	6	6½	7½	9½	6	8	9	7	8	6½	6½	9	10	10	6	10	7
5	7½	6⅔	7	5	6	5	6	0	5	6	4	10	6	6	8	8	6	7	7	6
6	5	0	0	0	3	2	5	0	0	5	2	1	2	1	0	0	4	0	1	1
7	10	10	10	7	9½	6⅓	9	8	7	10	8	5	9	9	5	10	6	6	8	8
8	10	10	5	0	3	9	3	0	5	0	6	1	5	5	0	0	8	6	10	5
9	5	5	8	6	7½	5	7½	5	7½	8	6	10	6	6	10	7½	8	6	7	7
10	10	10	5	5	5	4½	8	1	5	7	3	10	5	5	8	10	6	5	5	5
Total	80	72	62	44	62¼	59⅓	69½	31	53½	61	58	70	58½	57½	32	39	65½	58	70	62

RUSSIAN EXPERIMENTS CONFIRM MILLIKAN'S SUPER-X-RAY FIND.

The discovery of super-x-rays, consisting of extremely short-wave radiations coming to the earth from outer space, possessed of tremendously high penetrating power, has been confirmed by two Russian scientists, Dr. L. Myssowsky and Dr. L. Tuwim, who have repeated parts of the experiments performed by Dr. R. A. Millikan in the United States and Dr. Kolhorster, the German pioneer in super-x-ray research.

The Russian scientists made tests of the penetrating power of the rays by sinking specially arranged electroscopes beneath the waters of Lake Onega in Western Russia, and found that the rays were quenched at a depth of 19 meters, or about 60 feet. This was the depth determined by Dr. Millikan in California mountain lakes, and by Dr. Kolhorster in the Bosphorus during the World War. Waves able to pass through this depth of water, plus the thickness of the earth's atmosphere through which they come on their way from outer space, have a penetrating power, according to the physicists' calculations, that would carry them through six feet of land.—*Science News.*

ONE HUNDREDTH MEETING OF N. E. A. C. T.

The 100th meeting of the N. E. A. C. T. was held Saturday, May 1, at Boston College, Newton, Mass., preceded by a banquet the night before at the Ambassador, Boston. About forty teachers were present at the banquet and one hundred at the regular meeting. Dr. James F. Norris, president of the A. C. S. and past president of the N. E. A. C. T. was the main speaker of the evening. Dr. Norris' topic was "Chemistry and the Public." A silent tribute was paid at the start of the banquet to the memory of the vice-president, Herbert F. Davison, Brown University, whose sudden death occurred Apr. 28. Other speakers were President Johnson, Ex-Presidents Cowan, Obear and Stone.

The regular meeting Saturday morning started with an address of welcome by Rev. James H. Dolan, president of the College. Rev. John F. Brosnan gave an interesting discussion of color photography, illustrated by still and moving pictures. Dr. C. E. Bolser, Dartmouth College repeated his interesting talk on "Chemistry and Medicine." Numerous committee reports were given and the election of officers completed the morning program. The association was the guest of the college at a substantial lunch.

At the afternoon meeting a tribute prepared by Dr. L. C. Newell, and Messrs. Berry and Ricker in honor of Dr. Davison was read. This was followed by a very interesting talk on the "Relation of Organic Chemistry to Industry" by Dr. Charles H. Herty, president of the National Organic Chemical Manufacturers Association.

The new officers of the association are as follows:

Officers for which nominations must be made: For the Association as a whole—president, Alfred M. Butler, Practical Arts High School, Boston; vice-president, Elwin Damon, Keene, New Hampshire; secretary, John H. Card, English High, Boston; assistant secretary, Octavia Chapin, Malden, Mass.; treasurer, Shipley Ricker, Woburn, Mass.; auditor, S. Walter Hoyt, Mechanic Arts H. S., Boston; curator, Dr. Lyman C. Newell, Boston University. For regional divisions—Central Divison, Chairman, Martin S. Sanborn, Everett, Mass.; Northern Division, Chairman, Harriet Lyseth, Augusta, Maine; Southern Division, Chairman, Raymond R. Thompson, Auburn, R. I.; Western Division, Chairman, Prof. C. R. Hoover, Wesleyan University, Middletown, Conn.

Contributing editors to the Journal of Chemical Education: Maine, C. A. Braulecht, University of Maine; New Hampshire, E. B. Hartshorn, Dartmouth College; Vermont, L. O. Johnson, Rutland High School; Massachusetts, S. W. Hoyt, Mechanic Arts High Schoool, Boston; Rhode Island, R. R. Thompson, Auburn High School; Connecticut, Grover Greenwood, Bridgeport High School.

Senate of Chemical Education: Maine College, C. A. Brautlecht, University of Maine; High School, L. W. Riggs, Portland, Maine; Independent, A. E. Lachor, Rumford Falls; New Hampshire College, A. J. Scarlett, Dartmouth College; High School, W. Segerblom, Exeter Academy; Independent, H. K. Moore, Berlin, N. H.; Vermont College, P. C. Voter, Middlebury; High School, L. O. Johnson, Rutland; Independent, O. Winestock, Perkinsville; Massachusetts College, J. S. Chamberlain, Mass. Agricultural College; High School, L. P. Patten, Medford; Independent, G. J. Esselen, Boston; Rhode Island College,............ High School, R. R. Thompson, Auburn; Independent, A. H. Fiske, Providence; Connecticut College, G. A. Hill, Wesleyan; High School, H. S. Wessels, New Briton; Independent, W. L. Scott, Manchester.

A Tribute to Herbert F. Davison.

A committee, consisting of Lyman C. Newell, Arthur H. Berry and Shipley W. Ricker, presented this tribute to Herbert F. Davison. It was read while the members stood with bowed heads. At the close it was voted to spread it upon the minutes of the meeting and to send a copy to Mrs. Davison.

The death of Herbert F. Davison has removed from the New England Association of Chemistry Teachers a man whose generosity and ability had won our deepest admiration and genuine esteem.

As chairman of the Southern Division and later vice-president, he was an industrious and energetic officer of this association. His many contributions to our programs, always so willingly made, will long be remembered by us for their specific originality and immediate usefulness.

As a demonstrator of lecture experiments, Mr. Davison was unsurpassed. As a college teacher, too, he was a constant inspiration to his students and maintained their interest not only by his skill as a lecturer but also by his keen appreciation of their needs as learners. His success as a teacher was due largely to the fact that his mastery of his subject and skill in presentation did not cloud his conception of the difficulties of beginning students.

Mr. Davison was a modest man and no doubt this trait delayed somewhat the professional recognition of his marked ability as a teacher.

The New England Association of Chemistry Teachers desires at this time and in this way to make a formal and permanent record of its loss.

BOOKS RECEIVED.

Chalk Talks on Health and Safety, by W. Cobb, M. D., Director of Physical Education and Hygiene, public schools, Baltimore. Pages vi+243. 14x19 cm. Cloth, 1925. The Macmillan Co., New York.

Great Rivers of the World, A Story of Their Service to Man, by W. S. Dakin, Regional Supervisor, Connecticut State Board of Education. 14x19 cm. Pages vii+204. Cloth, 1925. The Macmillan Co.

Our Own United States, by W. Lefferts. Pages ix+344. 13x19 cm. Cloth, 1925. J. B. Lippincott Co., Philadelphia.

Physics of the Home, by Frederick A. Osborn, University of Washington. Pages 291. 14x22 cm. Cloth, 1925. No. 3. University Book Store, Seattle, Wash.

Everyday Science Projects, by Edith Lillian Smith. Pages vi+341. 13x19 cm. Cloth, 1925. 96 cents. Houghton, Mifflin & Co., Boston, Mass.

Science of Home and Community, revised edition, by Gilbert H. Trafton, State Teachers College, Mankato, Minn. Pages xiii+578. 13x20 cm. Cloth, 1926. The Macmillan Co., New York.

Seeing America, Book Two, Mill and Factory, by W. B. Pitkin and H. F. Hughes. Pages 333. 14x19 cm. Cloth, 1926. The Macmillan Co.

BOOK REVIEWS.

Introductory College Chemistry, by Harry N. Holmes, Professor of Chemistry in Oberlin College. New edition. Pages viii+500. 15x22x3.2 cm. Illustrated. Cloth, 1925. Macmillan.

Not to "temper the wind to the shorn lamb" but to prepare a somewhat shorter, and perhaps a bit simpler text than the author's book of 1921, this new college chemistry text was gotten out. Frequent recent consultation of the book in connection with reference work by a project class in high school chemistry has convinced the reviewer that, while the book may have been shortened somewhat, there is still vastly more material in it than there is any hope of really putting across with any class of college freshmen. The teacher will as always have to select what he regards as the more essential things and omit many of the others. The book is thoroughly up to date having some of the high spots of the theory of atomic structure added to the chapter on the periodic law and carrying a good chapter on colloid chemistry. Positive and negative valence are discussed in the chapter on valence. Considerable organic chemistry is included in order to give those students who will go no further in chemistry a chance to glimpse some of the marvelous results of the two faced conduct of carbon and to see the relation between the compounds of carbon and daily life.

Going into the presentation of the subject-matter we find that the material is taught in such a way that it is easily received by anyone who has the necessary ability and interest in the work. The teaching of mass action is a case in point, the subject being approached in an admirable manner. College teachers will profit by considering this new text.

One or more copies should be in every high school chemistry library.

F. B. W.

Everyday Science Projects, by Edith Lillian Smith. Pages vi+341. 13x19 cm. Cloth, 1925. 96 cents. Houghton, Mifflin & Co., Boston, Mass.

Everyday Science Projects is a textbook for grades five, six, and seven. Designed to serve as an introduction to the Study of General Science. It is also suitable for use as a supplementary reader. Its purpose is to show boys and girls that science enters into their everyday experiences. The book is divided into three parts, with Autumn, containing eight sections; Winter, with nine sections, and Spring and Summer, with seven sections. There are also six pages of suggestions for teachers. There are over 300 projects.

The book is written in a very interesting style, well adapted to the children for whom it is written. There are 156 illustrations. At the end of each project is a well selected list of "Books That Will Help You." It is the best book of its kind that the reviewer has ever read.

C. M. T.

Physics of the Home. A Textbook for Home Economics Students in Normal Schools, Colleges and Universities, by Frederick A. Osborn, Professor of Physics, University of Washington. Pages 291. 14x22 cm. Cloth, 1925. Price $3.00. University Book Store, Seattle, Wash.

The book is a combination text and laboratory manual. It is the result of a course that has been given for ten years to domestic science students. It is offered as the first formal attempt to meet the needs of women students who desire to know physics for its real help in their daily lives. There are thirty-three chapters, each containing suggested laboratory exercises and a well-selected list of illustrative problems. Mechanically, the book is well made; the only serious objection being the small size of type used, eight point. Ten point would be much easier on the eyes. A change of type now and then would add greatly to the appearance of the printed page. The book is well written and the various subjects treated in a way that will prove especially well adapted to women students.

C. M. T.

Science of Home and Community, a textbook in general science, revised edition, by Gilbert H. Trafton, State Teachers' College, Mankato, Minn. Pages xiii+578. 13x20 cm. Cloth, 1926. The Macmillan Co., New York.

This is not merely a revision of the author's former textbook on General Science but is practically a new book. It is right up to date. For example, an entire chapter is given to radio with many illustrations, entire chapters are on aeroplanes and airships, automobiles, trolley cars, steamboats, and the locomotives. The book is divided into two parts. Part 1, Science of the Home, with fourteen chapters. Part 2, Science of the Community, with eighteen chapters. Part I has the following sections: (A) Building the Home; (B) Hygiene of the Home; (C) Electricity in the Home; (D) Recreation in the Home; (E) Use of the Home Grounds. Part II, (A) Means of Travel; (B) Means of Communication; (C) Health of the Community; (D) Community Entertainment; (E) Conservation of Community Resources; (F) Weather and Climate; and (G) The Earth and its Neighbors. The practical work of the book is divided into four kinds, laboratory exercises, demonstrations, field work, and projects. A very valuable feature of the book is the use of common words instead of technical words, wherever possible. This is one of the most interesting texts on general science that the reviewer has ever read. Every general science teacher should become acquainted with it. C. M. T.

Seeing America, Book Two, Mill and Factory, by W. B. Pitkin and H. F. Hughes. Pages 333. 14x19 cm. Cloth, 1926. The Macmillan Co., New York.

This is a most interesting little book for boys and girls. The authors have presented in story form the basic geographic principles that are foremost in our country. It presents to our boys and girls an idea of the machine age in which we live. Two boys visit all sections of the United States and ask all manner of questions. The book is well illustrated with half toned photographs of mills and processes. C. M. T.

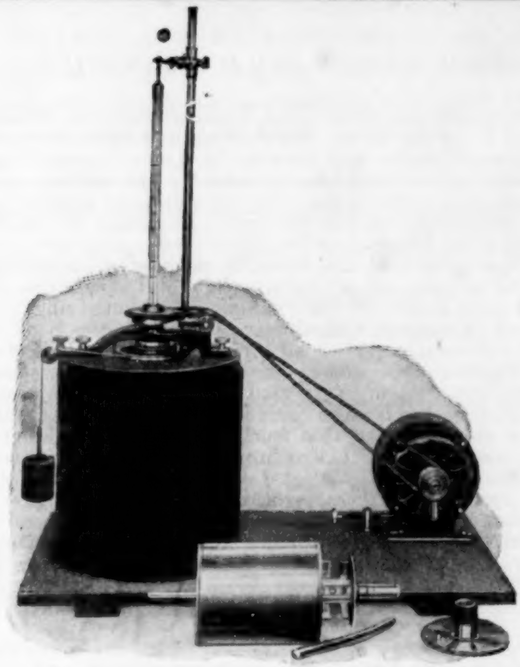
TO ENCIRCLE CITIES WITH NATIONAL FORESTS.

Ten million acres of national forests in ten years encircling the great cities and industrial regions of the United States, is the ambitious program which received the endorsement of the second annual National Conference on Outdoor Recreation meeting in Washington recently.

The program calls for the acquisition of two and one-half million acres in the Great Lakes region, from three to four million acres in the region of the White Mountains and the Appalachians, and two and one-half million acres of the remaining pine forests in the South. It is expected that these great zones of wilderness will not only provide breathing-places for the dense population of the great commercial and industrial centers but will more than pay for themselves under a policy of scientific forest management. The toleration of destructive unregulated grazing of stock in national forests was opposed by the Conference.

The Conference also placed itself on record as favoring the proposed extension of the Yellowstone National Park to include the headwaters of the Yellowstone River and the Teton Mountain range, and boundary adjustments of Rocky Mountain, Grand Canyon, Sequoia and Mount Rainier national parks. It also backed the Game Refuge Bill, and endorsed the policy of federal aid for highways.

The National Conference on Outdoor Recreation was called into being by President Coolidge in 1924, as a means of coordinating the activities of the numerous organizations interested in various aspects of outdoor life in America. In addition to official delegates of the Federal and State governments about one hundred independent organizations were represented at the meeting.—*Science Service.*



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